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P.74

PROCEEDINGS

OF THE

BELFAST

Natural History and Philosophical Society,

FOR THE

SESSION 1871-72,

WITH OBITUARY NOTICE OF THE LATE ROBERT PATTERSON ESQ., F.R.S.

BELFAST:
PRINTED AT THE "NORTHERN WHIG" OFFICES, VICTORIA STREET.

1873.

S. 14.

Belfast Natural History and Philosophical Society.

ESTABLISHED 1821.

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PREFACE.

In the Annual Report of the Society, dated 30th May, 1872, the intention of issuing the present volume was announced by the Council to the Shareholders and Members, in the following paragraph :—

> "After mature deliberation, your Council have resolved that it would be advisable to publish regular 'Proceedings' of this Society; and, with this view, they have been procuring either full reports or condensed abstracts of the papers read during the past session."

In the succeeding Annual Report, dated 5th June, 1873, the following paragraph appeared :—

> "The Council announced last year their intention of publishing regular 'Proceedings' of the Society. Owing to the difficulty of procuring the requisite manuscripts from the respective authors, more delay has occurred than was anticipated in the preparation of the first volume. Its editing has been entrusted to your President, Mr. Joseph John Murphy, and one of your Secretaries. Dr. Henry Burden. Under the superintendence of these two gentlemen the volume is now approaching completion."

It is not necessary to make any further prefatory remarks, except to say that repeatedly during the Society's existence, from the year 1821 till the present year, 1873, the Council had observed with regret that, from want of a publication like the present one, many most valuable communications laid before the Society had lost that permanent place to which their originality or merit entitled them.

The next volume of "Proceedings" will comprise the papers read from November, 1872, till May, 1873. The materials for it are being at present collected; and the two gentlemen already mentioned, Mr. Murphy and Dr. Burden, have kindly consented to continue their editorial supervision.

Belfast Museum,
College Square North,
July, 1873.

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PRESIDENTIAL ADDRESS

ON MOTIVE POWER,

DELIVERED BY

JOSEPH JOHN MURPHY, Esq.,

ON NOVEMBER 1st, 1871.

As you have again done me the honour of electing me your President, it becomes my duty, according to custom, to open the session with an address, either on the general position of science, or on some particular scientific subject, or set of subjects. For the former of these two tasks—namely, for an entire review of the present state of science and of its progress during the past year, I am, however, quite incompetent; and I regret this the less, because I do not believe that the past year has witnessed any great new discovery, or any totally new page opened in the book of nature, which could be compared for general interest with such a discovery as, for instance, that of spectrum analysis, or with such researches as those of Dr. Carpenter and Dr. Wyville Thomson respecting the depths of the ocean, their climates, and their living inhabitants. Perhaps the most important of all very recent contributions to pure science is that which has been made by my fellow-member and Vice-President, Dr. Andrews, in his thoroughly original researches on the relation between the gaseous and liquid states of matter; but on this subject I do not intend to say anything, as you are to hear a lecture on it from Professor Thomson, who is thoroughly qualified to do it justice.

In the results of applied science, the past few years have been fruitful. It is not more than five or six years since the practicability of that most marvellous of all engineering enterprises, the Atlantic

Telegraph, was proved by its becoming a working reality, though I believe that its ultimate success was a matter of certainty to those who knew how to read the lessons derived from the failure of the first attempt. Since then the Suez Canal, which, as a project, was, I believe, generations, if not centuries old, has been opened for traffic; and during the last few weeks the Mont Cenis tunnel under the Alps has been completed, so as to give uninterrupted railway communication from the Straits of Dover to the farthest extremity of Italy. The success of these enterprises may, of course, be expected to lead to the undertaking of others, some of them perhaps even more gigantic. The Atlantic Telegraph was the first of a set of submarine lines which will before long, in all probability, bring the most distant parts of the world into instantaneous communication. The completion of the Suez Canal will probably be followed by the construction of a canal connecting the Atlantic and Pacific Oceans, by one of the several routes through Central America and the Isthmus of Panama, which appear to be more or less practicable. And the successful completion of the Mont Cenis tunnel is already leading to the revival of the project for connecting England and France by a tunnel under the Straits of Dover. There can be no doubt of the possibility of carrying such a project into effect. The length is not unmanageably great—little more than twenty miles; and, what is quite as important, the greatest depth is but a very few hundred feet. But the cost would be so enormous that we must probably wait for an indefinite time before it is seriously attempted, especially as there are no political reasons for undertaking it as Government work. A railway tunnel between Scotland and Ireland has been proposed, to go from near Cushendall to the Mull of Cantyre; and a detailed description, with estimate cost, has been published by the Belfast engineering firm of Macassey and Scott. If there were no special engineering difficulties, it might be worth while for the Imperial Parliament to spend many millions on a work which would practically make Ireland cease to be an island. There is nothing impracticable in the length of such a tunnel, which, at the narrowest part of the channel, would be less than fifteen miles; but I fear, though I speak under correction, that the depth of water, which is very considerable, would constitute an almost insurmountable difficulty.

The Mont Cenis tunnel has not been made for profit. Had it been left to commercial enterprise, it would probably not have been commenced yet. It was planned for political purposes by that great statesman to whom the kingdom of Italy owes its existence. At the time of the annexation of Savoy to France, the French Government consented to share the expense, but it continued under the direction of the Italian Government and Italian engineers. Italy is the native land of engineering. The Romans were the great road-makers of the ancient world, and the Etruscans appear to have been the inventors of the arch, or, if they did not actually invent it, they were the first discoverers of its vast utility. The modern Italians of the same period, when their paintings became the admiration of the world, distinguished themselves also in the engineering art; that most useful and admirably simple, though by no means obvious invention—the canal lock—is due to them. The work of the Mont Cenis tunnel is of itself enough to show that the old engineering genius is not extinct. It was carried out under peculiar difficulties in a thoroughly original manner. The tunnel was worked from the two ends only. The great height of the mountain overhead prevented the use of those vertical shafts, which are used to give access to the workings from above when the tunnel is not too far below the surface. We have all heard, and admired as we heard, how the workmen, beginning from opposite sides of the mountain, worked on till they met in its midst, without either being more than half-a-yard to the right or left of the other. But this result, thoroughly creditable as it is, is not more wonderful than the precision to which we are accustomed in astronomical observations. The originality of the work consists in the machinery by which the tunnel has been excavated. It was driven through hard rock which had to be blasted. Now, in the process of blasting, as every one is probably aware, though the removal of the masses of stone is effected by the force of the gunpowder or other explosive substance, yet a great deal of hard work is required to make the holes in the rock in which the charges of gunpowder are placed. In such a work as the Mont Cenis tunnel, the expense of doing this by hand-labour would probably have been enormous, and, moreover the time required for so doing would, no doubt have been much greater than what was actually required. It was necessary to do the work by

machinery. But what was to be the motive power? Steam is what one naturally thinks of; for the steam-engine is far superior to any other motor yet known to man, in the facility with which it can be applied in any place and with any force. But to its employment in this work there were two formidable objections. One of these was its great expensiveness. In many, perhaps most, engineering and mechanical works, the cost of coals to work the steam-engines is a considerable item of expense; and, though I do not know at what price coals could have been delivered at the Mont Cenis, yet, no doubt, their cost would have been much higher than what we are accustomed to in this country. Another objection, and perhaps a still more important one, would have been the difficulty of ventilation. Where there is a steam-engine there must be a furnace; with any ordinary way of transmitting power, the engine, with its furnace, must be near the machine which it drives. But how could a furnace be kept burning in a tunnel without suffocating the workmen—especially as each of the tunnel workings had only one outlet until the two met each other in the middle of the mountain? Had the old engineering methods been employed, this difficulty, if it could have been surmounted at all, must have been surmounted in one of two ways. The smoke and heated air from the furnace might have been brought to the mouth of the tunnel through a pipe; but by the time the working had got to the middle of the mountain, the pipe must been more than three miles long, and if a draft along a horizontal chimney of such a length could have been obtained at all, it could only have been obtained by great expenditure of steam-power, employed either directly as a jet after the manner used in railway engines, or in working a fan. Or the engine must have been placed outside the tunnel, and the boring machine worked from it by means of a long wire rope; but this way of transmitting motive power is very awkward and objectionable for such long distances.

These difficulties were overcome, not by surmounting them, but by setting them aside. It often shows more generalship to pass by a hostile stronghold than to take it, and it showed far higher genius in the engineers of the Mont Cenis tunnel to invent a new kind of machinery for their purpose than to contend, however successfully, with the difficulties of the old-fashioned kind. The expense of fuel for steam-power, and the difficulty of ventilation, were both got rid of by

the employment of water-power instead of steam. Water-power is abundant in the Alps, and it seldom fails, even in the heats of Summer, because the streams continue to be supplied from the melting snows. But it was obviously impossible to apply the water-power in any usual way. It would be scarcely practicable to set up water-wheels in the tunnel workings; and the objection to work the boring machines by means of wire ropes, carried into the tunnel from the outside, would have been the same with water-power as with steam. These difficulties were perfectly overcome in a way which was, I believe, completely original. Water-wheels, under any modification, were discarded. The hydraulic pressure of the falling water was directly employed in closed vessels to compress air. The air thus compressed was brought in pipes to the boring machines in the tunnel workings, where its expansive force was directly employed in driving the boring chisels against the rock. There were two secondary but most valuable advantages in this way of applying the motive power. The air, after expanding and doing its work in hammering at the rock, of course escaped and mingled with the air of the tunnel, and thus a constant supply of fresh air was ensured in a place where it was much needed, in consequence of the breath of the workmen, the heated and vitiated air from their lamps, and the smoke from the gunpowder used in blasting. But this was not all. The air thus supplied was not only fresh but cold; it was cooled by the act of expanding; and thus were the workings kept comparatively cool, which would otherwise have been oppressively hot, not only from breath and smoke, but also from the internal heat of the earth; for this internal heat is found to increase, as theory would lead us to expect, not only in working downwards from the surface, as in a coal-pit, but in working horizontally away from the surface, as in a tunnel through a mountain. It ought to be mentioned that the machine for boring by means of chisels, worked by compressed air, was the invention of Mr. Bartlett, an English engineer; it had been patented, but I believe never brought into use. But Mr. Bartlett, who was not thinking of Alpine railways, intended to compress the air for his machine by steam-power. The hydraulic apparatus used at the Mont Cenis tunnel was invented by the engineers of that work. But there is a disadvantage in compressed air as a means of transmitting motive power from the hydraulic engine or the steam-engine, whence the

power is derived to the machine which it is to work. The cold produced in the expansion of the air at the boring machine is the equivalent of a corresponding quantity of heat, which was produced in its compression at the hydraulic engine. If the heat thus produced continued to heat the compressed air, it would add to its expansive force, and all the motive power stored up in condensing the air would be given out in its expansion. But this is an impracticable condition: the heat, or at least a great part of it, cannot be prevented from escaping through the walls of the air-vessels and pipes; and the air, by thus cooling, loses part of its expansive force. The loss of motive power from this cause is very great—I believe about one-half. That is to say, the work which can be done by any hydraulic or steam-engine, when the motive power has to be transmitted over a long distance by means of compressed air, is only about the half of the work which might be done if the machine to be driven were close to the engine that drives it. At the Mont Cenis, where the motive power of falling water is to be had without cost, and probably in unlimited quantity, this kind of waste was a matter of no account, in comparison with the great convenience and adaptability of the system; but in places where water or steam-power is expensive, it must be an almost conclusive objection to its use.

It is, however, probable that a great variety of useful applications remain to be made of the system of transmitting motive power by means of compressed air. One which has already been tried may prove to be of first-rate importance. Machines have been constructed, and have at least succeded as experiements, for excavating or "hewing" coal by means of compressed air. It would be obviously out of the question to work a number of small steam-engines in all parts of a coal mine, in consequence of the danger of setting the mine on fire, as well as the difficulty of obtaining sufficient ventilation to carry of the smoke and heated air. But where the beds of coal are thick, it is quite practicable to do the "hewing" by means of a pick worked by machinery, provided only that a safe and applicable motive power can be found. Compressed air is such a motive power. The air is compressed by a machine worked by a steam-engine above ground, and transmitted in flexible tubes to the various hewing machines, which, of course, must be moveable. Besides saving human labour, these

machines get the coal in larger blocks and with less waste ; and in a coal mine, as in the Mont Cenis tunnel, the escape of compressed air has the two great incidental advantages that it assists ventilation and produces cold.

For general purposes the compressed-air system has the great advantage that power can be laid on anywhere, like gas or water. A compressed air-pipe may be laid as easily as a gas or water-pipe, so that power can be brought wherever it is wanted, without the inconvenience, dirt and perhaps danger of a steam-furnace. At the place where the power is to be applied in working machinery, there must of course be an engine resembling a steam-engine of very simple construction, and worked by the expansive force of the compressed air. Even with steam power there is great convenience in this manner of working. There is a growing tendency in mechanical engineering to convey the motive power to the different machines of a manufactory by means of steam-pipes instead of shafts and gearing—that is to say, where formerly there would have been one large steam-engine working all the machines by means of shafts, there is now a small steam cylinder to work each separate machine, all, however, being supplied with steam from one boiler. The new system is in various ways more convenient than the old, and it is also more secure against that frightful disaster, technically called the "breaking-down" of a steam-engine ; but I do not think it can tend to economy of steam and fuel. Of course, there must be a limit to its application ; no one would propose to have a separate steam-engine for each spinning frame and each loom ; but I understand that in at least one spinning-mill in England there is a small steam-engine on each floor, instead of one large one to drive the entire mill ; and that in one of the largest calico-printing works in Scotland each printing machine is driven by a separate steam-cylinder. This system of dividing the steam power is most applicable where the separate machines to be worked are heavy, and where they are not constantly but intermittently at work. It has also, besides being in general safer from a "breakdown," the advantage of greater safety in some particular cases. Thus in hoisting heavy weights there is less danger of a disastrous and fatal "breakdown" when the engine works the windlass directly, than when there is intermediate gearing ; and where it is needful to be at any time able to reverse the motion,

it is far safer to reverse the steam-engine itself than to have to depend on reversing gear. The tendency to employ separate steam-engines for separate work is, however, only part of a general tendency to use steam power as directly as possible, and to avoid gearing or other machinery intervening between the steam and that which it works. It has always been considered good engineering to work a pump directly from the beam of a steam-engine; indeed, it was for this work the steam-engine was first invented. Paddle steamers and railway engines have, I believe, been worked from the first without gearing, the crank shaft being also the wheel shaft. In screw-steamers the speed of the screw was at first got up by gearing, but now "direct action" is universal in them also. But the action of steam is now applied in far more direct ways than these. That most valuable instrument, the steam hammer, is not a hammer driven by a steam-engine, but a hammer driven by steam. It is attached to the piston-rod of a steam cylinder which has no crank motion or gearing, so that the action of the steam is as direct as that of a workman on the hammer which he holds in his hand. There are other applications of steam power which do not even need a cylinder and piston. The "Injector," used for supplying boilers with water, is a jet pump, in which the water is carried up the pipe along with a rush of steam. A few years ago I saw what is essentially the same contrivance at work in Paris for the purpose of cleaning the fronts of the houses in the Rue de Rivoli. A jet of steam, carrying water in the form of spray, played on the stone, and cleaned it as if by a peculiarly effective brush, so as to restore the original beautiful whiteness, which had become dimmed by smoke. The boiler and furnace were not large enough to obstruct the traffic. I do not know what effect this kind of steam brush would have on the dingy bricks of Belfast, but I greatly wish to see it applied to the stone, originally white but now almost black, of Westminister Abbey and St. Paul's, and of the Bank of Ireland. But the most remarkable of all these direct applications of steam power is a recent American invention for cutting the hardest stones, and even glass, by means of a jet of steam, carrying with it a shower of quartz sand. This method appears to make what were formerly the most difficult stones perfectly easy to cut, but it will not polish. For all these purposes of direct action, there is no

reason why compressed air should not be as applicable as steam. Indeed, the boring apparatus used in excavating the Mont Cenis tunnel consisted essentially of a set of hammers, or rather chisels, worked by the expansive force of compressed air, as the steam hammer is worked by steam. And compressed air has also the advantage which steam has not, when it is not wanted for immediate use as motive power it may be stored in a reservoir, so that the steam-engine or hydraulic-engine which compresses the air may continue at work while the machines that it supplies are stopped, accidentally or during the workmen's meal-times; and also during the night if it is found practicable to make the reservoir large enough, so that the motive power will not be wasted.

But, as I have mentioned already, the method of storing and transmitting motive power by means of compressed air is eventually wasteful, in consequence of the escape of heat. There is another way of storing and transmitting power which is free from this objection, and for most purposes is equally manageable and convenient with that of compressed air—I mean by hydraulic pressure. This system has been worked out by Sir William Armstrong, and forms a far better claim to the gratitude of mankind than his inventions in artillery; indeed, I think few persons have yet perceived its immense possible usefulness. Like the compressed air system, the hydraulic system is applicable to the purpose of storing up and giving out the power due either to a steam-engine or to a water-wheel, or any other kind of hydraulic engine. The steam or hydraulic engine works a force-pump, which exerts pressure exactly like that of the well-known hydraulic press used in packing bales of goods. Wherever work is to be done a pipe is laid from the force-pump, and the pressure of the water in the pipe works a hydraulic-engine somewhat resembling a steam-engine of very simple construction, for this, under great pressures, is preferable to any kind of water-wheel. The hydraulic pressure under which Sir William Armstrong works his machines is very great, being in some cases more than that which is due to a column of water a thousand feet high. So far as I have yet described, this is only an apparatus for transmitting motive power along the water-pipes. But there is an apparatus attached to it for also storing the power. This consists in an enormous weight, which is raised by the hydraulic pressure in the

pipes proceeding from the force-pump—when the machines which are worked by the hydraulic pressure are stopped the pressure expends itself in raising the weight, thus storing up motive power; when on the contrary, the machines are at work, the weight decends and gives out the power which it had stored up. The chief application which has as yet been made of this invention is in cases where very heavy work has to be done in a very short time, especially in raising weights, so that a force-pump driven by a comparatively small steam-engine may be at work for an hour or more in raising the weight of the accumulator until the motive power is required for the use; and then the power accumulated during an hour may be given out and used in a minute, and a small steam-engine may do work which otherwise would only be done by a very large one.

But the principle of accumulated and transmitted hydraulic pressure appears capable of much wider application than this. There must be many establishments where it would be desirable to have mechanical power for the purpose of raising weights, working hydraulic presses, and other kinds of work that cannot be classed as manufacturing, and yet where it is not desirable to put up a steam-engine with its dirt, and the addition which it entails to the cost of fire insurance. It might be a great advantage to such establishments if they could be supplied with hydraulic power, brought from without in a pipe like gas; and companies might have good dividends by working the steam-engine, force-pump, and accumulator, which should supply such motive power. It would be impossible at present to form an estimate of the possible future demand for this kind of motive power; but I think it likely that it may be employed not only in warehouses, but in small manufactories which now use steam-engines. I understand that in Newcastle-on-Tyne the pressure of the water in the town pipes is used to work the cranes which discharge the ships; but this is admissible only where the supply of water for domestic purposes is superabundant—a condition which is yearly becoming more difficult to fulfil as our towns increase and our people acquire the habit of using more water. The consumption of water in Sir William Armstrong's hydraulic machines cannot be very great, in consequence of the high pressure at which it is used; and besides, for such a purpose, purity is of no importance, so that they need not interfere or compete with the domestic supply.

Perhaps, moreover, the plan of transmitting motive power by means of hydraulic pressure may hereafter be applied to work all the machinery of great manufacturing cities. It must have occured to many, not only to scientific men, but to those who pretend to nothing more than common sense, that there is a frightful waste in burning coals to supply steam-engines instead of using water power. There is no doubt that water-power is better than steam-power where it is to be had and relied on. But many falling streams are almost useless for mechanical purposes, because they cannot be relied on during the summer ; and others are equally useless because they are in remote and inaccessible places. The advantage of the steam-engine is, on the contrary, that it may be set up anywhere and kept constantly going. These disadvantages of uncertainty and remoteness, however, do not attach to all water-falls. At Niagara there must be enough water-power to drive all the machinery in the world, concentrated in one place, and easily accessible by means of railways and navigable rivers, This instance, though the greatest in the world, is by no means the only one of the kind ; and I can scarcely doubt that at some future time the manufacturing industries of the world, in so far as they do not depend on a supply of minerals or fuel, will be concentrated at places where there is a vast supply of water-power. But there may in some cases be considerable engineering difficulties to overcome before the power of a great waterfall can be brought to work all the machinery of a great manufacturing town. A waterfall may be in the heart of a populous country and yet be difficult to get at. I have not seen Niagara, but I have seen what may be called a miniature European Niagara—namely, the Falls of Schaffhausen on the Rhine, where a large river falls through a height of sixty feet. There is certainly enough of power in that one place to work the machinery of a great manufacturing town. But how is it to be made available? Schaffhausen, though in Switzerland, is not among mountains, but the Rhine there flows at the bottom of a ravine, somewhat like that of the Menai Straits. So far as I can judge from merely seeing the locality, very expensive engineering works would be needed in order to make any great part of the water which now flows over the falls available for working the water-wheels of manufactories, and the manufactories would have to be placed in very inconvenient positions. It occurs to

me, though the idea may prove impractical, that the best way of utilising such a water-power as that of Schaffhausen would be to employ it in working one or few enormous hydraulic-engines, which should drive force-pumps and charge accumulators, from which hydraulic pressure should be laid on by means of water-pipes to the various manufactories, where it was required to work the machinery on Sir William Armstrong's system. If it was found practicable to make the accumulators large enough, they might be charged during the night for work during the day, and thus the efficiency of the hydraulic engines worked by the river would be doubled.

The hydraulic system which I have been describing stores motive power in the accumulator simply by raising a weight. This may appear a primitive and unscientific contrivance, but no better is known. Its capacity for storing motive power is very limited ; it stores it only from hour to hour. Its ability to transmit power is also limited to such distances as are not too great to make it feasible to lay a water-pipe. And it does not in any degree tend to make motive power portable ; the enormous weight of the accumulator effectually forbids this. In two of these respects the compressed air system is on a level with the hydraulic system; it is not capable of storing a large quantity of motive power, and it can transmit it only along a pipe. But the compressed air system appears to have the advantage of offering a possibility of making motive power portable. When we see the Mont Cenis tunnel bored by water power, it is reasonable to ask if the railways, and especially the steep slopes leading up to the tunnel on each side, could not be also worked by water-power, so as to save the great expense of fuel? The objection to this is, that water power is stationary, and stationary power can be employed for railway traction only by means of wire ropes—an awkward system which is generally condemned by engineers. But why should not compressed air be employed instead of steam for railway locomotives ? The air should of course be compressed in a stationary reservoir, and transferred from it to a reservoir in the locomotive engine. It would be necessary, in order to carry enough of motive power in the very limited space that could be afforded in the locomotive, to compress the air much more than has been done in the Mont Cenis works. The air was there compressed to a sixth or a seventh of its ordinary volume. For the purpose of working a

locomotive engine, it ought, perhaps, to be compressed to a fiftieth or less. But there is nothing impracticable in this; it only would require very strong vessels to contain the air. This system was once proposed for our railways—the air being compressed by a condensing air-pump worked by a stationary steam-engine. This proposal, however, was based on an exaggerated estimate of the advantage of stationary over locomotive steam-engines, and did not offer any real benefit. But the case is very different where water-power is to be had in unlimited abundance, and where the price of fuel is far above what we are accustomed to. Unless the water-power of the Alps can be utilised in either this or some other way for the purpose of working the steep and long gradients of the Alpine railways, I should think their working expenses for steam-power will be enormous, and will make it impossible for them to carry a large traffic in heavy merchandise at paying rates. But if cheap water-power can be substituted for costly steam-power, the expense of working railways will not be greater in the Alps than anywhere else; and, moreover, it will not be needful in the case of future railways to go to such enormous expense as that incurred in making the Mont Cenis tunnel, the chief purpose of which is to diminish the height up which trains have to be drawn on each side of the mountain. This subject is one of great importance. The Mont Cenis is not the only Alpine railway. A railway has been made over the Brenner Pass by the Austrian Government, uniting the German and the Italian parts of the Tyrol; and another has been commenced by the same government over the Arlberg Pass, to unite the Tyrol with the Lake of Constance. Both of these, I should think, like that of the Mont Cenis, are military and political lines, undertaken without any prospect of direct profit. The Brenner and Arlberg Passes are both much lower than the Mont Cenis. But another Alpine railway is to be shortly commenced, which will be a work of the same magnitude as the Mont Cenis—I mean the line which is to unite the railways of Germany with these of Italy through Central Switzerland, past the Lake of Lucerne, and through the St. Gothard Pass over the Alps. This line is, I believe, undertaken by the Swiss Government, not with any hope of direct profit, but in order to prevent the trade which has hitherto passed through Switzerland from being diverted away to the Mont Cenis railway on the one side, and the Brenner on the

other, and the Governments of Germany and Italy are, I believe, giving some assistance from commercial motives. No doubt the intelligent and carefully educated engineers of Switzerland will avail themselves for this great work of the experience gained in making the Mont Cenis tunnel, and will introduce improvments of their own. According to an account of the project which appeared two or three years ago in the *Revue des Deux Mondes*, it is intended not only to work from both ends at once, but, at the same time, to begin in the middle, by sinking a shaft near Hospenthal. But on this railway, as on that of Mont Cenis, there will be a very heavy ascent towards the entrance of the tunnel at each end. The chief drawback to the usefulness of Alpine railways, I should think, will not be so much the expense of construction as the expense of working ; and if this can be over-come by the employment of water-power in any form, Alpine districts may be hereafter almost as thickly intersected with railways as lowland ones.

There is another way in which it may perhaps be yet found practicable to use water-power for the purpose of transit. I mean in the navigation of rapid streams. Very rapid streams are generally regarded as almost incapable of navigation, even when like those which flow out of the Swiss lakes, they are of tolerably constant volume, and without many obstructions in the waterway ; or if they can be navigated at all, it is only by rafts of timber, or by barges which cannot re-ascend the stream, and must consequently be broken up when they arrive at their destination. If it were possible to use the water-power of the current for the purpose of drawing the barges upward, many rivers would be made navigable which are not so ; and provided that the waterway was clear, the rapidity of a river would be no longer one of the most formidable hindrances to its navigation, but, up to a certain limit, rather a help, the navigation, both upwards and downwards, being thus independent of its steam power. But how is this to be effected? How is the force of the current to be applied in order to draw vessels upward? There may be, and probably there are, great practical difficulties in doing this, but theoretically it is very simple. To explain this I will mention those floating water-mills which many Continental travellers must have seen on the Rhine. They have an external resemblance to paddle-

steamers; there is an "undershot" water-wheel on each side, resembling the paddle of a steamer, and propelled by the current. Now, suppose that the paddle-shaft were to work a windlass, and this windlass to pass under a wire rope which should lie in the bed of the river except when the windless draws it up, then the force of the stream working the water-wheels would become a motive power, whereby the boat would work itself up stream along the rope. This mode of propulsion is the same in principle as that employed by a man who stands in a boat and moves it along by drawing up a rope which is fastened on the shore. This idea of using the current for the purpose of propelling a boat against the current is very obvious, and by no means new. It might, perhaps, have been carried into effect before now, but for the great success of steam navigation. It is not, however, to be now thought of as a rival to steam, but as a method of navigating streams which are not now navigable at all. There are, no doubt, great difficulties to be overcome in any mechanical arrangement in which it is necessary to rely much on ropes; but it will, perhaps, be found that these difficulties have been much diminished by the greater improvments which the necessities of the submarine telegraph of late years caused to be introduced in the construction of ropes, where strength has to be combined with lightness. The notion of propelling a boat by the force of the current against the current, may, perhaps, suggest that of propelling a ship by the force of the wind against the wind. This was one of the many projects that floated in the inventive brain of our late fellow-member, Mr. Mitchell. But I have been informed by Dr. Robinson, of Armagh, a much higher authority, that this is not only practically but theoretically impossible.

The subject of motive power is one which concerns far wider interests than Alpine railways, or the navigation of rapid rivers. The duration of the supplies of coal has till now been generally regarded as a question of only speculative interest, but it may in the course of the next few generations become one of the utmost practical importance. During the present year a Royal Commission, after carefully examining the evidence, has reported on the subject, and to the following effect:—Supposing that mining is practicable to the depth of 4,000 feet and no more, so that the coal within 4,000 feet of the surface is alone available, the stock of available coal in the

United Kingdom, including both those beds which we now are working and those which are ascertained to exist, but are not yet opened, amounts to at the nearest approximation about 146 thousand million tons. Now, at the present yearly rate of consumption, which is 115 million tons, this would last for 1,273 years. But the consumption of coal is rapidly on the increase ; and though no estimate of the future increased rate of consumption can be anything more than an arithmetical exercise, yet we may safely say that, as matters stand at present, we have not within 4,000 feet of the surface nearly enough of coal to last us for 1,000 years, and that if exhaustion is to come within 1,000 years increasing scarcity will begin to be felt at a comparatively early date. It appears scarcely possible that any extensive discoveries of coal remain to be made, at least in Great Britain ; and if any should be made in Ireland, it can scarcely be thonght that they will add any large percentage to the entire quantity. The report has not taken the peat of our Irish bogs into account ; but though this is part of our stock of fuel, I do not think it can be large in comparsion with the coal. It appears, however, by no means certain, though the Royal Commission has taken it for granted, that mining works must stop short when, or before, they arrive at 4,000 feet of depth. As a merely engineering operation, there is scarcely any limit to the depth to which a mine may be sunk ; and the increased expense of working at the greatest depths is much less than might be expected, and would add but little to the cost of the coal at the surface. The only dificulty in the deepest workings will be that arising from the internal heat of the earth ; but this is no doubt a most formidable one. The temperature of the earth is found to increase by one degree of Fahrenheit's thermometer for every fifty or sixty feet of descent ; and it is probable that this increase goes on uniformly to a greater depth than the deepest mine is likely ever to reach. At this rate the temperature at a depth of 4,000 feet must be considerably above that of the human body ; and if the temperature of a mine is not much below this, it appears certain that mining cannot be continued below 4,000 feet. All then depends on the working of the mine. But this ought not to be very difficult. The deeper the mine the more easily will it be ventilated, for the same reason that the highest chimney is that which draws best. Further,

any quantity of cold may be produced in the mine by compressing air at the surface, and permitting it to escape below; while in escaping it may work machinery, as I have already mentioned, for "hewing" the coal, and for improving the ventilation. I believe Sir William Thomson is of opinion that there will be no insuperable difficulty in keeping down the temperature sufficently in the deepest mines that can be worked. I think then that the prospect is less discouraging than the report of the Royal Commission would make it appear. But it is sufficiently serious to make it a national duty to act on the supposition of our stock of fuel being limited. If the system of mining coal is in any district needlessly wasteful, it is certainly the duty of the Legislature to prevent this. And further, I thoroughly agree with the eminent economist and philosopher John Stuart Mill, that in this generation, while coal, which is the chief physical basis of our prosperity, is still abundant, and when we have got rid of every tax, without a single exception, which is objectionable in principle, we ought earnestly to endeavour to pay off our National Debt. If no unforseen interruption occurs to our prosperity, it would be possible to pay off the National Debt in the course of a few generations, without burthening ourselves in any injurious way; and we ought to set this before ourselves as an end to be attained.

Legislation probably can do nothing to enforce an economical method of using coal; but in this direction engineers and men of science may do much. The margin for economy, however, in the use of the steam-engine at least, is narrower than many persons are apt to think. A certain quantity of motive power is due to the combustion of a given quantity of coal, just as a certain quantity of motive power is due to the fall of a given quantity of water through a given height; and all that the profoundest engineering science can hope to do is to utilise this power with the least possible percentage of loss. In hydraulic machinery perfection appears to be already attained. The best constructed water-wheels utilise about eighty per cent. of the whole, and much better than this is not to be hoped for. In the steam-engine nothing at all approaching to this has been attained: there is still a very wide margin of waste for engineers to try to save. The engine itself, however, including the valve gear, on which the economy of steam depends, appears to be already brought

to perfection. Most of the improvements in the steam-engine since its invention by James Watt have for their object to make it not more economical of coal, but cheaper, lighter, and more manageable and capable of adaptation to various purposes. Engineers, however, have been endeavouring for many years past, and with a good deal of success, to make the steam-engine more economical. Economy of fuel is to be sought for chiefly not in the engine itself, but in the boiler and furnace. The steam ought to be admitted into the cylinder at the highest pressure which is consistent with safety; for heat is most economically applied when the pressure is highest; in other words, it is when the pressure of the steam is highest that the greatest proportion of the heat becomes available as motive power, and the waste is smallest. And the furnace ought to be so constructed as to waste as little heat as possible. The steam-engine will not have been brought to perfection until the governor is applied to regulate, not the admission of steam into the cylinder, but the admission of air into the furnace. In these two ways—wasting as little heat out of the furnace as possible, but employing it all for raising and heating steam, and using the steam at the highest practicable pressure—there is, I believe, a wide margin left for engineers to save. And here, though legislation can do nothing directly, it may do much indirectly. I mean by providing our artisans and our engineers with the best technical education based on science. It is not in the use of steam-power alone that there is a wide margin for the saving of fuel; there are probably very few furnaces which are not very wasteful. The waste is probably largest of all in the iron manufacture, because it is that manufacture which consumes the largest quantities of coal. An admirable invention has been made of late years, which appears to be applicable to all furnaces, for the purpose of saving their waste heat. It is applied with great success at two well-known establishments in this neighbourhood—the Castle Espie lime-works, and Mr. Moore's brick-works. The plan of working is briefly thus :—The hot air from the furnace, before it goes up the chimney, is brought through a series of pigeon-holes of brick. In these bricks it deposits its heat, and goes up the chimney nearly cool. After a while the direction of the draft is reversed, and the air going to feed the fire is made to flow through those heated bricks,

which yield up their heat to it, so that the air is already heated when it flows into the furnace. Of course special modifications of this invention will be needed for each kind of furnace, and it will, no doubt, be long before it has received all the applications of which it is capable.

Some one who has heard my remarks on the possible improvement of the steam-engine, may perhaps be inclined to think that all this may any day be rendered superfluous by the discovery of a new motive power. I fear this is not to be hoped for. The more we know of the forces of the universe and their laws, the less probability does there appear to be of any new force being discovered. Some years ago many persons hoped much from the substitution of heated air for steam in engines. But this would not be a new motive power. The motive power of the steam-engine is heat, and the proposed change would be only the substitution of air for steam as the vehicle of the heat. At an earlier period great things were expected from electricity as a motive power. But this was altogether a delusion. It is impossible to obtain motive power without the expenditure of material. The material expended in a steam-engine is fuel, and that expended in an electric engine is zinc or other metal, whch is oxidised in the battery; and metals are so much nore expensive than coal, that any expectation of economy by substituting them for coal must be fallacious.

It is sometimes said we may yet succeed in burning water, for water contains hydrogen, and hydrogen is combustible. Unfortunately, however, this is quite a misconception. Hydrogen, no doubt, is combustible, but when burned it forms water; thus water is burned hydrogen, and neither hydrogen nor anything else will burn again after being burned once. If it could, we should have an inexhaustible source of heat; but the existence of this is inconsistent with the laws of nature. It is altogether fallacious to speak of the motive power, or heat, or electric force, locked up in a drop of water. It is not in the water; it was in the hydrogen and oxygen of the water before they combined; they have parted with it in the act of combining, and it has most probably been radiated away into space. The hydrogen and oxygen of water, no doubt, cling to each other with a great force which is capable of being measured; but this is mere static force, not capable of con-

version into motive power. As well might we seek to find motive power in the pressure of the sea on its bed.

But I do not see anything impossible or beyond hoping for in the discovery of some way of storing motive power, for an unlimited time and in indefinite quantities, and at the same time making it portable. If it were possible, for instance, to store the water power of Niagara or Schaffhausen, and to send it wherever it was wanted, what an industrial revolution this would produce, second only, if second, to that due to the invention of the steam.engine ! It is not only water power that might be thus employed. The power of the wind is now almost discarded in consequence of its inconstancy, but, if it could be stored, it would be a motive power available everywhere, and the working of machinery would no longer depend on the supply of coal or the accidental presence of water power. All nations would be benefitted by such an invention. It used to be said that our coal mines gave us an advantage in manufactures over all other nations, but this is a mistake as to the fact. We have no natural monoply of coal. Germany contains rich beds of coal. Our fellow-member, Mr. Boyd, once told us of an enormously rich one which be had surveyed in Poland. The United States contain richer coal beds, and at a less depth, than any in Britain ; and in every part of the world mineral wealth generally appears to be more abundant the more it is explored.

But it is quite possible that no great improvement in the application of motive power may ever be made ; and it is our duty to do what we can to economise our resources so far as possible. Most of the great inventions of the past century have been for the purpose of saving labour ; but it appears probable that not very much more remains to be done in this way, except in bringing into general use the inventions already made, and in inventors in the future doing more towards economising material. It appears probable, also, that purely mechanical invention is comparatively exhausted, and that the most productive field for invention in future will be chemistry. The economising and utilising of waste materials is a growing part of our industry. I will only mention, as the most remarkable instance of this, the wonderful discovery of the process for making the beautiful and durable aniline dyes from what used to be almost a waste material—namely, coal-tar. This, however, is not an invention of first-rate im-

portance, though its scientific interest is very great. By far the most important problem now before engineers is to save the waste and noxious materials which pollute the rivers that flow past our cities, and to convert them into the means of fertility for the land. We are beginning to see our way to doing this; and I hope that many of us may live to see it effected universally.

Although these remarks on the present state of engineering science are not the work of an engineer, I hope they may not be thought out of place or worthless. One of the best presidential addresses ever delivered to the British Association was by the Duke of Argyll, who, like myself, is not a professional man of science, but only an amateur; and I believe that many professional men of science will admit that they have received from amateurs, not perhaps information nor even particular suggestions, but what is quite as valuable—namely, intellectual impulse.

November 29, 1871.

JOSEPH JOHN MURPHY, ESQ., the President of the Society, in the Chair.

A Paper was read by Professor JAMES THOMSON, LL.D., entitled—

SPECULATIONS ON THE CONTINUITY OF THE FLUID STATE OF MATTER, AND ON TRANSITIONS BETWEEN THE GASEOUS, THE LIQUID, AND THE SOLID STATES.

THE author commenced by referring to two recent communications made by him to the Royal Society of London*, and the British Association† in which he had advanced some new views as to relations among the states of matter commonly named, distinctively, the Gaseous, the Liquid, and the Solid states. The paper, of which an abstract is given here, was arranged for the purpose of submitting to this society an account of the chief new views comprised in those two previous papers, together with such additional explanations and illustrations as might tend to render the subject generally intelligible; and farther, in this new paper some later theoretical considerations, constituting an additional development of one part of the subject, were, for the first time, brought forward.‡

The question may be asked at the outset, *What is to be understood by the three states—the Gaseous, the Liquid, and the Solid?* These names are familiar to all of us, and we are all accustomed to asso-

* Royal Society Proceedings, No. 130, 1871.

† British Association Transactions, Edinburgh Meeting 1871, page 30.

‡ See page 32, where there are introduced considerations showing the way in which the curves between gas and liquid, and between gas and solid, must cross one another.

ciate each with some idea, more or less definite, of a character or condition of matter. We have all been long accustomed to conceive of matter as existing in one or other of three states spoken of as the gaseous, the liquid, and the solid states. The transition from each of these to any other has usually been regarded as abrupt ; or at least this may be said, if we except the as yet imperfectly understood phenomena of gradual hardening of some substances such as melted glass, or melted pure iron. We have been accustomed to notice, as among the usual properties of liquids kept at any of various temperatures, their powerfully resisting compression, and gradually, but very slightly, expanding on the diminution of the pressure to which they are exposed, till they attain a certain volume dependent on their temperature, beyond which volume they will not admit of farther gradual expansion with gradual diminution of pressure, but at which, with no change of pressure, an abrupt augmentation of volume supervenes, accompanied by the sudden attainment of a greatly altered set of characters and properties commonly recognised as specially pertaining to the gaseous state of matter. Among these altered properties, one of the most remarkable is that of unlimited farther gradual expansibility by farther gradual reduction of pressure. The abrupt change of volume and of other properties thus noticed, has ordinarily been understood as an absolute and complete separation between all liquid states and all gaseous states of the same matter. It is now found, however, that this distinction is incomplete ; and that it is insufficient to separate any one state, or set of states, from any other state or set of states ; or to form a separation or distinction between what in common language are called liquids, and what in common language are called gases.

If we consider water and steam present together in mutual contact in a boiler or in a glass flask heated by a flame or otherwise, we observe a very decided distinction between the liquid water, and the steam, or gaseous water-substance, enclosed together in the vessel. The two are identical in substance, they have both the same pressure (one atmosphere if the vessel is open), and they have both the same temperature (100° Centigrade ; the ordinary boiling temperature, if the vessel is open). Yet while both of them are alike in substance, and in pressure, and in temperature, they are very different in density, or in volume for a given mass ; and very different too in

respect to their possession of latent heat. Here we have a sharp definite distinction of two states with a perfectly abrupt change from the one to the other, called evaporation or condensation, which is effected without any change whatever of either pressure or temperature.

Having here a perfectly abrupt distinction, we can properly speak of the two states under different names, *liquid* and *gaseous*.

But now, to view the matter otherwise, let us commence with this liquid water and steam in mutual contact; and, whatever be their existing temperature and consequent pressure, density, and latent heat, let us for distinction call the existing condition of each its original condition; and let us take some of the liquid water away from the steam, and treat it separately. We can cool this water, and so bring it to a new condition. We can then at pleasure either relieve it from so much pressure, or we can compress it more; and in either case we effect another alteration of its state or condition. When we have it under more than its original pressure, we can heat it to more than its original temperature, and thus we bring it into yet another new condition or state. We can make as many such changes as we please, in varied ways, without meeting any abrupt change at all; or without finding any change sufficient to lead us to suspect any important alteration to have occurred requiring a new name for a new state. We only say that the liquid water has been cooled or compressed, or relieved of pressure, or compressed and warmed, or otherwise changed, by separate or combined changes of temperature and pressure; but we consider the fluid dealt with as being still liquid water in continuously variable conditions. The steam, too, which was originally in contact with the water; and so had the same temperature and pressure as the water had; is, if taken away from the water and treated separately, capable of undergoing gradually varied changes of state or condition quite corresponding to those already described which the liquid water is capable of undergoing. Thus, for instance, the steam or gaseous water-substance may without any sudden or abrupt change be raised in temperature, or lowered in pressure, or altered in both these ways conjointly, or it may be raised in temperature and raised in pressure also; and, from each state so attained to every other, transitions may be effected in an infinite variety of perfectly gradual ways. Thus

we have seen (1st), that between water and steam in contact with one another, there is an abrupt transition; (2nd), that the water-substance, taken initially in its liquid condition when in contact with the steam, admits of receiving an infinite variety of perfectly gradual changes of state; (3rd), that the water-substance, taken initially in its gaseous condition when in contact with the liquid water, admits of receiving an infinite variety of perfectly gradual changes of state. Now, farther, through the researches and discoveries of Dr. Andrews in recent years, we are led to conclude that these varied states of the water, and varied states of the steam, in their wide divergence from the initial conditions of the water and steam in mutual contact; which were alike with one another in pressure and temperature, but quite distinct in other respects; come to meet again: and in coming to this new meeting, very different from their previous abrupt meeting, they merge perfectly gradually into one another. He has shown by experiments on carbonic acid and several other substances, that the ordinary gaseous and the ordinary liquid states are only widely separated forms of the same condition of matter, and may be made to pass into one another by a course of continuous physical changes presenting nowhere any interruption or breach of continuity.

These experiments of Dr. Andrews are to be found described in detail in his original memoir in the "Transactions of the Royal Society for 1869," and they have been explained by himself to the Belfast Natural History and Philosophical Society. The carbonic acid or other fluid experimented on was confined in the upper part of a small glass tube, hermetically sealed at the upper end, the cavity for containing the fluid being made variable in capacity at pleasure by an arrangement for forcing in a mercurial column from below more or less by means of a hand screw. He made experiments on the effects of changes of pressure and of temperature on various fluids; but carbonic acid was the one which he selected for his most extensive and elaborate experiments. He had means provided for making observations on the co-existing pressures, temperatures, and volumes of the carbonic acid in successive experiments, with all requisite accuracy for the establishment of very remarkable conclusions. In this apparatus, when gaseous carbonic acid commencing with a light pressure is enclosed and maintained at any ordinary temperature of the atmosphere, at, for instance, 10° Centigrade or 50° Fahr., it

shows liquefaction on being compressed. The liquid carbonic acid may be seen lying in the bottom of the cavity with gaseous carbonic acid above it, there being a visible surface of demarcation between the two.

But, otherwise, if this same carbonic acid, still enclosed in the cavity, be taken at first at 10° Centigrade as before, and at any pressure which allows it to remain gaseous, and if it be warmed to any temperature above 31° Cent. (that is to say, above 88° Fahr.), it may, at this higher temperature, be subjected to any pressure, however great, without showing any liquefaction. While subject to heavy pressure, it may be cooled to its original temperature of 10° Cent., and yet no appearance of liquefaction will have set in, though it be now in a state even more dense than when it was in the previous example compressed at 10° to the liquid state from the gaseous. It may now, while maintained at 10° Cent., be relieved of pressure, till at last it will begin to boil; thereby showing that it is now liquid and must have really passed from the gaseous to the liquid state, through elevated temperatures and pressures, by a series of gradual changes presenting nowhere any interruption or breach of continuity. Through this abrupt process of boiling, it reverts to the gaseous state; yet it has nowhere passed through the contrary abrupt process of condensing. Again, the reverse of this entire cycle of operations may be effected. We may this time commence at 10° Centigrade, with the cavity containing gaseous carbonic acid at top, and liquid carbonic acid below. Compress so as to diminish the volume, and condensation from gas to liquid will set in, and with continued diminution of volume will go on, without any change of temperature or pressure, till no part remains gaseous. Retaining the same temperature of 10°, press more heavily and then raise the temperature. Thus the critical temperature of 31° Cent. may be surpassed without boiling setting in. Now enlarge the cavity maintaining any temperature above 31° Cent., and the confined fluid, which we may have hitherto regarded as liquid, enlarges with the cavity and abates in pressure without boiling or showing any appearance of evaporation. Continue this process till the pressure in abating reverts to its original amount. We may now lower the temperature, retaining this regained original pressure, and on arriving at 10° Cent., while diminishing the volume, we shall find the fluid beginning to show liquefaction setting in, so that we may

be sure it is now gaseous. Thus we have had a gradual transition from the liquid state to the gaseous state made manifest without any abrupt change such as that of boiling or evaporation having occurred.

We may next consider a series of changes during which gaseous and liquid carbonic acid are kept constantly present together in the cavity. Suppose that we commence at an ordinary atmospheric temperature of 10° Centigrade, and that we have already compressed gaseous carbonic acid till a portion of it has condensed to the liquid state. We are now to proceed by raising the temperature and raising the pressure so as to keep the fluid continually partly liquid and partly gaseous; and so we are to keep continually passing through a succession of boiling or condensing points of pressure and temperature jointly. To do this we may proceed thus :—

(1.) Maintaining the volume constant, heat the heterogeneous fluid, but not so much as to evaporate the whole. This causes a part of the liquid to evaporate, and expands the remainder in spite of the increased pressure of the gas above. This makes the remaining liquid less dense and the gas more dense than before; and so the two have approached nearer to one another in density.

(2.) Keeping temperature constant, diminish the cavity, compressing its contents so as to condense to the liquid state what had evaporated in the previous process. This does not alter the pressure, but leaves the original quantities in the liquid and gaseous states, and nearer to one another in density than at first. Go on in the same way by heating and compressing and taking care so to modulate the two processes as to maintain always a portion of the fluid gaseous and a portion liquid. The two operations of heating, and diminishing the volume, might equally well be carried on simultaneously; but perhaps the changes may be more clearly understood by conceiving the two processes as kept distinct, and, considering their effects, separately. In this way, as the temperature and pressure are augmented, the gaseous part is always increasing in density, and the liquid part is diminishing in density, till at last the two come to have the same density with one another, and then they are perfectly alike in every respect, all distinction between them having vanished.

At this stage the temperature is 31° Cent., and the pressure is about 75 atmospheres. Above this temperature of 31° no change of

pressure can cause gasification or liquefaction ; and above this pressure of about 75 atmospheres, no change of temperature can cause gasification or liquefaction.

If we denote geometrically all possible points of temperature and pressure jointly, by points spread continuously in a plane surface, each point in the plane being referred to two axes of rectangular coordinates, so that one of its ordinates shall represent the pressure and the other the temperature denoted by that point, and if we mark all the successive boiling or condensing points of pressure and temperature as a continuous line on this plane, this line, which may be called *the boiling-line*, will be a separating boundary between the regions of the plane corresponding to the ordinary liquid state and those corresponding to the ordinary gaseous state. But by consideration of Dr. Andrews's experimental results, we may see that this separating boundary comes to an end at a point of temperature and pressure which, in conformity with his language, may be called the *critical point* of pressure and temperature jointly ; and we may see that from any ordinary liquid state to any ordinary gaseous state the transition may be gradually effected by an infinite variety of courses passing round the extreme end of the boiling-line.

Fig 1.

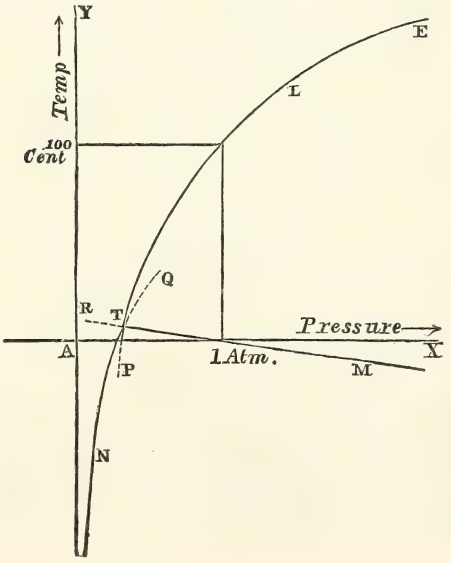


Fig. 1 is a diagram to illustrate these considerations and some allied considerations to which they lead in reference to transitions between the three states, the gaseous, the liquid, and the solid. This figure is intended only as a sketch to illustrate principles, and is not drawn according to measurements for any particular substance, though the main features of the curves shown in it are meant to relate in a general way to the substance of water, steam, and ice. A X and A Y are the axes of coordinates for pressures and temperatures respectively; A, the origin, being taken as the zero for pressures and as the zero for temperatures on the Centigrade scale. The curve L represents the boiling-line. This terminates towards one direction in the *critical point* E ; and it passes in the other direction to T, the point of pressure and temperature where solidification sets in. This point T is to be noticed as a remarkable point of pressure and temperature, as being the point at which alone the substance, pure from admixture with other substances, can exist in three states, solid, liquid, and gaseous, together in contact with one another. In making this statement, however, the author wishes to submit it subject to some reserve in respect to conditions not as yet known with perfect certainty. He observes that we might not be quite safe in assuming that the melting-point of ice solidified from the gaseous state is the same as the melting-point of ice frozen from the liquid state, and in making other suppositions, such as that the same quantity of heat would become latent in the melting of equal quantities of ice formed in these two ways. Such considerations as these into which we are forced if we attempt to sketch out the course of the boiling-line, and to examine along with it the corresponding boundary-lines between liquid and solid and between gas and solid, may be useful in suggesting questions for experimental and theoretical investigation which may have been generally overlooked before. Proceeding, however, upon assumptions such as usually are tacitly made, of identity in the thermal and dynamic conditions of pure ice solidified in different ways, the author points out that we must suppose the three curves (namely, the line between gas and liquid, the line between liquid and solid, and the line between gas and solid) to meet in one point, shown at T in the figure. This point of pressure and temperature for any substance may then be called *the triple point* for that substance. In the figure the line T M represents the line between liquid and solid. It is

drawn showing in an exaggerated degree the lowering of the freezing temperature of water by pressure, the exaggeration being necessary in order to allow small changes of temperature to be perceptible in the diagram. The line T N represents the line between the gaseous and the solid states of water substance. The two curves T L and T N, one between gas and liquid, and the other between gas and solid, have been constructed by Regnault for water-substance through a great range of temperatures and pressures, extending from —32° Centigrade to + 230° Centigrade, as an expression of the chief results of his experiments on the pressure of saturated aqueous gas at various temperatures above and below 0° Centigrade.* He has represented and discussed his results above and below the temperature at which the water freezes (which in strictness is not 0° C., but is the freezing temperature of water in contact with no atmosphere except its own gas), as if one continuous curve could extend for both. As brought out experimentally, indeed, they present so little appearance of any discontinuity that the distinctness of the two curves from one another might readily escape notice in the consideration of the experimental results. Prof. Thomson points out, however, that the range from temperatures below to temperatures above freezing comprises what ought to be regarded as two essentially distinct curves meeting one another in the point T; and he further suggests that continuations of these curves, sketched in as dotted lines T P and T Q, may have some theoretical or practical significance not yet fully discovered. He thinks it likely that out of the three curves at least the one, M T, between liquid and solid may have a practically attainable extension past T, as shown by the dotted continuation T R. Various known experiments seem to render this supposition tenable, whether the condition supposed may have been actually realised in experiments hitherto or not. He thinks, too, that there is much reason to suppose that the curve L T between gas and liquid has a practically attainable extension past T, as shown by the dotted continuation T P.

For so far the reasonings and explanations given here as to these three curves were comprised substantially in the author's paper submitted to the recent Edinburgh meeting of the British Association. In his paper of which the present is an abstract, he submitted to the Belfast Natural History and Philosophical Society some farther con-

* Mémoires de l'Académie des Sciences, 1847, pl. viii.

siderations developing more fully the features of the steam-with-water and steam-with-ice curves, and indicating the way in which these two curves, ordinarily regarded as one continuous curve, ought to be expected to cross one another. He explained to the effect that through the experiments of various investigators, and among the rest through those of Regnault, on pressures of aqueous vapour at various temperatures above and below the freezing point, it is fully determined that the line composed of two parts, L T and T N, presents in general for any portion long enough to extend through several degrees of temperature a decided character of convexity towards the axis of temperatures A Y. The question had farther arisen to him in his attempts to sketch out the curves so as to show, though in an exaggerated way, their proper features, whether the two curves, L T and N T, in meeting at T, should form with one-another a re-entrant angle, as is shown in the figure, or whether they ought to cross so as to form a salient angle, such as is exemplified in the vertex of a pointed arch. He gave reasons proving that the curves must be expected to cross, as shown in the figure with a re-entrant angle at T. These reasons may be briefly sketched as follows :—

Suppose that at first steam and water are present together at or above the temperature of the triple point. Reduce the temperature to below the freezing point while taking the necessary precautions to prevent the beginning of a change of state to ice. In reference to this it is to be observed that water can readily, in various circumstances, be cooled below the freezing point without freezing, but that the introduction of any particle of ice will afford a beginning of change of state, which, if the low temperature be maintained, will advance till the whole will become solid. As we lower the temperature from the triple point, we shall have the temperature and pressure jointly represented by successive points along the continuation of the steam-with-water curve prolonged into temperatures below the triple point, and shown in the figure by the dotted extension T P. Let the cooling and consequent abatement of pressure be continued till some point P on that curve is arrived at without the setting in of freezing. We may designate the temperature thus arrived at as $-t°$. Under these circumstances there is perfect freedom for transition either way between steam and water. Now, let a particle of ice be introduced into the liquid, and the water will strongly tend to become

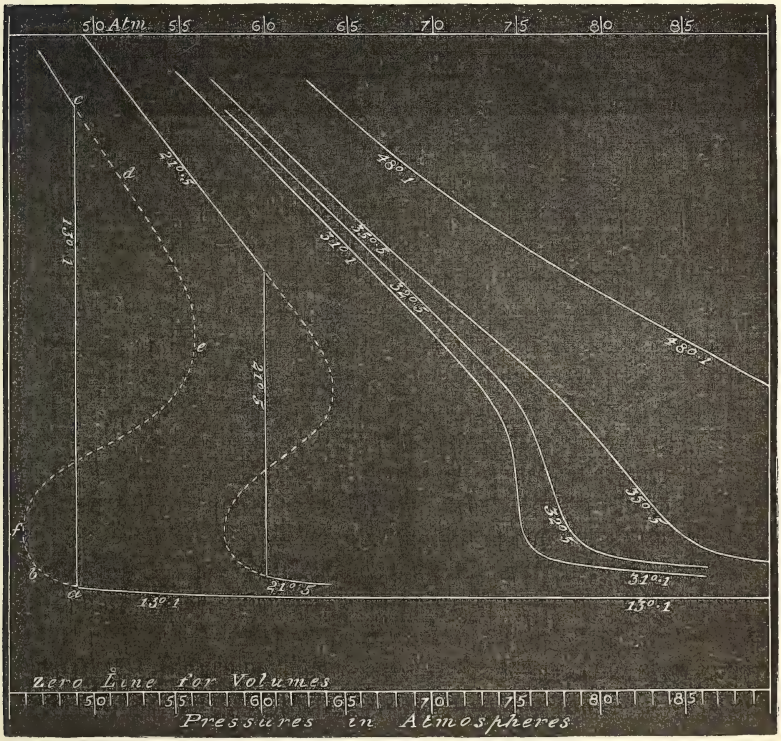
ice, if we maintain the same temperature and pressure as before; that is to say, the same temperature and pressure as are shown by the point P. The steam is free to become water, and the water is free to become steam; but the water strongly tends to become ice; and so the steam must tend to become ice; and thus it is obvious that there could be no condition of repose at this temperature and pressure without the whole water-substance having first become ice. Let us now retain the same temperature, but reduce the pressure. This change effects that there is no longer equilibrium between water and steam, but that the water has a decided tendency to become steam at its surface of contact with steam; and it leaves the tendency continuing in the water to become ice at its surface of contact with the ice. We may thus advance to so low a pressure for the unchanged temperature —t°, as will bring the result that if we were to have water, steam, and ice brought into mutual contact, the water would be just as strongly tending to become steam as to become ice, though it could not continue to be water; and so we would have arrived at a point of the steam-with-ice curve, and that point would be for the same temperature —t°, as was represented by the point P, but the pressure would be less than that of the point P. Thus we see that the steam-with-ice curve at the temperature —t° of the point P must be nearer to the axis of temperatures than P is; or, in other words, that the dotted line T P must lie, as drawn in the figure, on the side of T N, remote from the axis of temperatures. It can be proved in quite a similar way that, supposing the steam-with-ice curve to have an extension into temperatures above the freezing point, that extension must lie on the side of T L, remote from the axis of temperatures, as shown in the figure by the dotted line T Q.

The theoretical conclusions here brought out, the author suggests, are likely to admit of being experimentally tested and verified.

In reference to the continuity of the liquid and gaseous states, Prof. Thomson showed a model in which Dr. Andrews's curves for carbonic acid are combined in a curved surface, obtained from them, which is referred to three axes of rectangular co-ordinates, and is formed so that the three co-ordinates of each point in the curved surface shall represent, for any given mass of carbonic acid, a pressure, a temperature, and a volume, which can co-exist in that mass. This curved surface shows in a clear light the abrupt change or breach of

continuity at boiling or condensing, and the gradual transition round the extreme end of the boiling-line. Using this model and a diagram of curves represented here in Fig. 2, the author explained a view which had occurred to him, according to which it appears probable that although there be a practical breach of continuity in crossing the line of boiling-points from liquid to gas, or from gas to liquid, there may exist, in the nature of things, a theoretical continuity across this breach, having some real and true significance. The general character of this view may readily be seen by a glance at Fig. 2, in which Dr. Andrews's curves are shown by continuous lines (not dotted), and curved reflex junctions are shown by dotted lines

Fig 2.



connecting those of Dr. Andrews's curves which are abruptly interrupted at their boiling or condensing-points of pressure. It is to be

understood that each curve relates to one constant temperature, and that pressures are represented by the horizontal ordinates, and corresponding volumes of one mass of carbonic acid constant throughout all the curves are represented by the vertical ordinates. The author points out that, by experiments of Donny, Dufour, and others,* we have already proof that a continuation of the curve for the liquid state past the boiling stage for some distance, as shown dotted in Fig. 2, from *a* to some point *b* towards *f*, would correspond to states already attained. He thinks we need not despair of practically realizing the physical conditions corresponding to some extension of the gaseous curve such as from *c* to *d* in the figure. The overhanging part of the curve from *e* to *f* he thinks may represent a state in which there would be some kind of unstable equilibrium; and so, although the curve there appears to have some important theoretical significance, yet the states represented by its various points would be unattainable throughout any ordinary mass of the fluid. It seems to represent conditions of co-existent temperature, pressure, and volume, in which, if all parts of a mass of fluid were placed, it would be in equilibrium, but out of which it would be led to rush, partly into the rarer state of gas, and partly into the denser state of liquid, by the slightest inequality of temperature or of density in any part relatively to other parts.

* Donny, Ann. de Chimie, 1846, 3rd series, vol. xvi. p. 167; Dufour, Bibliothèque Universelle, Archives, 1861, vol. xii.

December 6th, 1871.

Joseph John Murphy, Esq., the President of the Society, in the Chair.

A Paper was read by J. D. EVERETT, M.A., D.C.L., entitled—

On the Reduction of Observations of Wet and Dry Thermometers.

After describing the attempts which have been made to lay down a rational formula for deducing the dew-point from observations of Wet and Dry Bulb Thermometers, the author called attention to the fact that these formulæ give better results when the old and erroneous value ·267 is employed for the specific heat of air than when the true value of ·237 is substituted.

The reasoning which has been employed in these attempts treats a thin film of air surrounding the wet bulb as heat tight and vapour tight, and supposes this film as soon as it has attained its permanent condition—that is to say, as soon as it has attained the temperature of the wet bulb and became saturated—to move away and be replaced by another. The possibility of leakage, either of vapour outwards from the film, or of heat inwards from the surrounding air, which is drier and warmer, is overlooked.

But it is certain that such leakage must occur; and only experiment can show whether its effect is more important as regards vapour or as regards heat. The author appealed to the above mentioned discrepancy as constituting an experimental proof that the latter is the case—that heat diffuses more readily than vapour.

Regnault's very elaborate experiments (Ann. de Chem., 1845), which were published some years before he had determined for himself the specific heat of air, show that when the air was at more than four-tenths of saturation, a value larger than the already too large value, ·267 gives better results ($\cdot 267 \times \frac{480}{429}$) ; but that is not the case when the fraction of saturation is less than four-tenths. The author of the present paper inferred from this result that the ratio of the diffusive power of heat to that of vapour increases as saturation is approached.

December 6, 1871.

Joseph John Murphy, Esq., the President of the Society, in the Chair.

On the same evening a Paper was read by ROBERT YOUNG, C.E., entitled—

Some Remarks on the Recent Changes of Coast Level at Ballyholme Bay, Co. Down.

A large section of the series of recent beds which are exhibited at this place, from measurements lately made on the spot, was shown and explained. Beginning at the South-West side, where the Lower Silurian Slates rise at an angle of 80°, the following succession is observed going in the North-Eastern direction towards the other side of the Bay.

1st.—Boulder Clay of a strong red colour coming on against the polished and grooved surface of the slate rocks, which here afford the most unmistakeable evidence of enormous glacial action in a direction nearly North and South, and oblique to the strike of the beds.

This clay has its upper surface horizontal for a short distance from its junction with the slates at a level of six feet above high water mark, and then gradually sinks below the beach, and only appears again near Glennanna. The boulders which are promiscuously imbedded in this clay, are of a moderate bulk, not generally exceeding four or five inches diameter, and mostly consist of fragments of the traps, syenites, granites, and chalk rocks, which can be referred to Antrim, Derry, and Donegal.

Some of the chalk boulders are of a very remarkable density, highly polished and striated in the line of their longest axes, and are seemingly of a different nature from the Antrim chalk.

2nd.—A bed of dark sandy mud or silt, apparently similar to that which underlies the greater part of Belfast, and which can also be traced at Kilroot and other points on the Antrim Coast. It is about 18 inches thick, and lies conformably on the boulder clay, with which it accordingly dips under the beach, but does not again appear at the other side, as far as the writer has been able to ascertain.

At low water, and when a storm has removed the loose shingle, portions of trees, mostly of the alder and willow, are to be seen imbedded in the upper surface in a dark mud of decayed leaves and other vegetable matters. The trees are of a small size, and all that have been observed are in a rotten condition. The author was informed that the wings of beetles had been found in this bed.

3rd.—Above this the whole width of the bay is filled with thin beds of fine and coarse sand, gravel, and shingle, laid perfectly horizontal, and tailing out all round at land side upon the boulder clay, at an elevation of about 20 feet above high-water mark. The materials of these beds seem to have been mainly supplied by the Silurians of the district, and the form and surface-aspect of the shingle are characteristic of the action of the sea on a coast line where slate rocks form the track.

The conclusions that were drawn from the whole of the facts here were that there must have been a greater elevation of the land at the time when the trees were growing, to the extent of at least eight feet above present level, and that subsequently a subsidence to the extent of at least 30 feet took place, and again an elevation to the level at the present time.

In the discussion which followed it was stated by Dr. Andrews that in a partially submerged bed of peat which occurs at the mouth of the Woodburn River, near Carrickfergus, and which is evidently coeval with the mud bed at Ballyholme, hazel nuts had many years ago been found with the kernels converted into carbonate of lime. None have been found of late years.

December 20, 1871.

Joseph John Murphy, Esq., the President of the Society, in the Chair.

A Paper was read by JOHN ANDERSON, Esq., F.G.S.,

On the Geological Formations of the County Down.

It has often been remarked that the neighbourhood of Belfast is one of the best localities in the three kingdoms for the practical study of geology. Here are to be found within easy distance representatives of nearly all the formations which go to build up what is called the earth's crust. It is no less remarkable that the line of the valley of the Lagan, and the bed of the Belfast Lough, which separates the County of Down from the County of Antrim, seems also to divide two of the great geological periods from each other—the Palæozoic from the Mesozoic. Thus it is, that while in the County Antrim the observer finds himself in the Newer Life Period, he has only to pass into the County Down to find himself in the Ancient Life Period. The New Life Period, or Neozoic, as it has been called, is well represented in the County Antrim—splendid and much frequented sections are to be found at Collin Glen, Woodburn, and the Cave Hill. We have it surmounting what is known as the New Red Sandstone, and forming with it, and the overlying Basalt, that magnificent escarpment extending from Whitehead nearly to Lisburn, so ornamental to the neighbourhood. These Mesozoic rocks are far more attractive to the geologist than the low-lying dark-coloured Palæozoic rocks of the County Down, and consequently have received much more of his attention. There is one system of this period common to both counties, to which some consideration must be given. I refer to the New Red or Triassic. These form the bottom rocks of the Mesozoic

Period. They not only underlie the County Antrim rocks, but the lower beds of them, called the Bunter, occupy nearly the whole valley of the Lagan, and are found banked up against the Silurian rocks of the County Down to the South and East, flanking the rising ground the entire way from the County Armagh down to Belfast and Strangford Lough respectively. The line of junction of these two sets of rocks, which is exceedingly interesting to examine, passes down between Hillsboro' and Lisburn at Blaris ; it then crosses and re-crosses the river Lagan several times, dividing the grounds of Hillden and Lambeg. It strikes through Wilmont and Malone House demesnes, whence it takes an easterly direction, crossing the Lagan for the last time a short distance above Ward's cottage. It now follows the course of the river to near Annadale, and then crosses over to Newtownbreda Rectory, and skirting the Castlereagh hills, takes a more southerly direction, sweeping by the Knock to near Dundonald Railway Station, and so running parallel to that line to the East, until it reaches Comber, which it passes close by to the South, and is lost under the waters of Strangford Lough. Crossing over now to the Southern shore of Belfast Lough, we find the Triassic rocks again making their appearance, dipping beneath its waters and forming the coast line down to within a short distance of Cultra. Inland from thence they appear thrown up against the Silurian rocks of this part of the County Down, as before. The line of junction, passing South of Holywood and Merton, sweeps round the base of the hills beyond Sydenham, and passes between Belmont and Stormount. It then runs nearly due East to Dunleady House and Milecross, passing close to the Newtownards Railway Station. Here it takes a turn to the South through Mountstewart demesne and Greyabbey, the line of junction with the Silurian keeping about one-fourth of a mile inland from the Eastern shore of Lough Strangford down to Bloodyburn Bay, near Kircubbin. It will thus be seen that parts of those Triassic rocks not only occupy the valley of the Lagan and the bed of the Belfast Lough underlying the towns of Lisburn and Belfast, but that they also occupy another valley of considerable magnitude in the Palaezoic rocks of the County Down, stretching from the shore of Belfast Lough away in a South Easterly direction, underlying the towns of Newtownards, Comber, and Holywood, and continued under the waters of Strangford Lough.

The representatives of the Triassic system in this valley consist chiefly of denuded portions of the Keuper and Bunter divisions. The red marls so well developed on the opposite side of the Lough appear only in the form of waste on the County Down side. These two divisions may be seen in close proximity on the Holywood shore at low water opposite Ballymenoch, where they dip towards the North at an angle of some 20°. Further down they are traversed by trap dykes, which have in some cases altered their colour. About 200 yards on this side of Cultra Quay the *Survey*—[to which I am indebted for some of the details in this paper]—shows a nearly North and South fault, an upthrow to the East of about 300 feet, which brings the lower Limestone shale to the surface; and thus abruptly terminates the Triassic beds in that direction.

The space occupied by the Keuper and Bunter, along the valley from Belfast towards Newtownards, although in general covered by a thick deposit of boulder clay, exposes some good sections. One of the latter may be seen near Dundonald. It was the stone from this quarry which was used in the construction of our new docks. The former is well exposed at Scrabo Hill, showing a thickness of some 120 feet. It overlies the Bunter. It is very remarkable that both rocks here appear conformable, although their junction in Cheshire bears evidence of erosion and unconformity, and on the Continent, the Muschelkalk, a very different rock from either, is interposed between them. It is no less remarkable that although but slightly removed from the horizontal, sheets and dykes of igneous rock, penetrate and overlie without altering them perceptibly, and at Scrabo these again appear to be traversed by vertical dykes of a later date.

The surface of the Keuper is frequently rippled, and exhibits the appearance of sun cracks and rain pits, leading to the conclusion that during their formation the waters were retreating and shallow—probably cut off from the sea. Further evidence in this direction is given by the deep red tinge of some of these beds. It is not considered possible that the colouring matter, which consists chiefly of oxide of iron, could be imparted from solution in an open sea in sufficient quantity to colour the sediment. It is also improbable that the thick deposits of salt found in the Triassic marls elsewhere could be formed from the ocean. No footprints or traces of animal life have yet been found on these sands, nor have any well-authenticated plant remains been discovered.

The trap of Scrabo, according to Mr. A. Gages, is in composition identical with that which forms the cliff at Fair Head, and corresponds closely with that at Ballygalley Head. As the age of the County Antrim trap is now admitted to be Miocene, it may safely be inferred that the trap of Scrabo is of the same period. This confirms the views expressed by the late General Portlock many years ago, that the trap of Scrabo and Dundonald, in the County of Down, were but outliers of the large basaltic sheets of the County Antrim. If this opinion be correct, then we may assume that before the basaltic overflow the underlying formations which we see so abruptly cut off in the face of the escarpment on the County Antrim side were continued in whole or in part across the present valley of the Lagan into the County Down, and were afterwards eroded on that side down to the level of the Triassic, thus forming a floor for the Antrim sheet to pass over. Or we may suppose that the small active centre at Scrabo, sympathetic with that of the County Antrim, was of itself sufficient, through the trap dykes which are found ramifying the older Triassic rocks in the neighbourhood, to break through and spread over them the igneous masses which we now see covering them. The denuding influences in operation since these sands were deposited have been so great that, had it not been for the protection afforded by the harder overlying igneous mass, they would in all probability have been swept away entirely. Proof of this is given by the great thickness of the Keuper when so protected, and by its shelved away appearance from thence, as by the action of a mighty current; also by the deep accumulations of red sand and marl waste found in the more sheltered parts of the valley.

Proceeding downwards in the table of rocks, the next system said to be represented here is the Permian, the uppermost of the Palaezoic series. There are only two small patches now shown in this locality of what is supposed to have been at one time a very much larger deposit. The existence of one of these rests chiefly on the authority of the late Professor Jukes and of Mr. Du Noyer. It is to be found about two and a-half miles South-East of Moira, near Fortwilliam. It is composed chiefly of thin sandstones and slate breccias, with a few bands of Magnesian limestone, and rests apparently on the Lower Silurian. The other, at Cultra, has long been known, and its place established in the table of our Irish rocks by such men as Bryce,

MacAdam, King, and Jukes. The beds here occupy but a very small area between high and low water mark immediately below Rosavo. They are composed chiefly of Magnesian limestone, with occasional breccias of Silurian grits and slates, having reddish marls below, and rest unconformably on red and gray carbonaceous shales. These beds dip towards the sea at an angle of 20° to 30°. They are terminated on the East by a North and South fault, which is also the line of a whin dyke. It is very remarkable that the shales fonnd on the other side of this fault are carboniferous; so that, in point of fact, the carboniferous rocks surround and underlie the entire series. Professor King, who has made the Permian rocks his study, says that the Magnesian limestone of Cultra agrees closely in chemical composition with that at Hartlepool, Durham, which is known to be Permian, and that the fossils contained in the Cultra beds are identical with *Schizodus Schlotheimi*, *Pleurophorus Costatus*, *Bakewellia Antiqua*, all well-known characteristic life forms of the Permian age, and to these Mr. Bailie adds *Productus Horridus*, and *Turbo Helicinus*; and, more recently, Mr. Etheridge has named a doubtful specimen found at Cultra in 1869, by Mr. Samuel A. Stewart, *Bakewellia Antiqua.* Notwithstanding all this evidence as to the identity of these beds, Mr. Joseph Wright, F.G.S., of Donegall Street, Belfast, after spending an entire Summer's leisure in their minute examination, considers that the entire series belongs to the carboniferous, in which opinion the writer concurs, believing that *no well authenticated* Permian fossils have as yet been discovered in these beds. Those which have been named as such, so far as known here, are invariably obscure and imperfect, and therefore doubtful; and it is well known that Magnesian limestone is also found in other parts of Ireland in the carboniferous, and in England in the oolitic.

Passing still downwards, the next system represented in North Down is the Lower Carboniferous limestone, found only at Castle Espy, and the carboniferous shale found there and also at Cultra. When treating of the Triassic beds found on the Holywood shore, it was mentioned that, as these passed onwards towards Cultra, they were cut off by a fault, which brought up the Lower Carboniferous shale. These shales, with the exception of the patch of nominal Permian laid down upon them seaward, as already referred to, extend

from thence for about a mile down to near Craigavad, where they form a junction with the Silurian. The shales on this side of Cultra Quay are chiefly of a dark grey or slaty colour, some of them nearly black. These, with others more of a red and yellowish shade found opposite the road leading to the Cultra Railway Station, contain abundance of fossils characteristic of this formation, such as *Modiola Macadami;* the small crustacean, *Cythere;* scales of the fish *Holoptychius*, *ripple and rain marks*, *Mollusk tracks*, *Muchisonia Angulata*, *Orthoceras Inequiseptum*, *Cypricardia Sinuata.* Plant remains have also been found here in abundance, some of immense size, supposed to be *Knorria*—(spcimens of all produced.) The dip of these beds (25° to 40°), taken in conjunction with the numerous trap dykes, of which some eighteen are found in close proximity, and the several faults point to this period as having been, in this locality, one of very active internal disturbance, the contortion of some of the beds shewing also considerable lateral pressure. It should be mentioned here that from an analysis made by Dr. Hodges of the rocks east of the fault above referred to, they are found to contain nearly equal parts of carbonate of lime and magnesia, thus giving them a character very similar to the adjoining Permian.

The corresponding carboniferous shale beds at Castle Espy are not so well exposed as those at Cultra. Sufficient, however, is known of their structure and of the life remains found imbedded in them to prove their identity—they lie unconformably on highly inclined and contorted Silurian grits. Overlying these, conformably, rest the only carboniferous limestone rocks known in the Northern part of this county. These rocks are crystalline, and mostly salmon coloured. The beds vary in thickness, from 4 feet to 6 inches, and are occasionally interstratified with shales full of fossils. This formation is over 40 feet in thickness; it dips to the South at an angle of 15° to 20°, and is overlaid unconformably by the Triassic, extending from Belfast Lough. The Triassic is in turn overlaid by a covering of stiff boulder clay, in some places 40ft. to 50ft. thick, and so hard that blasting has to be resorted to for its removal. Rolled Liassic fossils are occasionally found here, and the surface of the limestone frequently exhibits Glacial markings, chiefly bearing N. West and S. East—(specimen shewn):—also of the following characteristic fossils found on the spot—*Actinoceras Giganteum*, *Orthis Resupinata*, *Productus Longispinus*, *Spirifera Bisculata*—all belonging to the lower series.

It is evident to the observer that these shales of Castle Espy, as well as the overlying limestone, extended at one time not only over to Cultra, but occupied also the whole of this portion of the County Down, long before the Triassic sands were deposited, and that they were afterwards denuded, leaving only these two patches behind. In no other way can the presence of these isolated remains of the Lower Carboniferous now found *in situ* at these two stations be accounted for. There is no such evidence forthcoming that the Upper Carboniferous, containing the coal measures, ever were deposited in this locality. If such ever were so deposited, it is equally clear that the denudation which followed was so great as to sweep them off entirely, leaving not a vestige behind. In these circumstances the idea seriously recommended by anonymous letter-writers in the newspapers of sinking for coal at Newtonbreda, Newtonards, Sydenham, and Holywood, is simply absurd.

The next rock in this part of the County Down, passing still downwards in the scale—and that usually found immediately beneath the surface soil—is the old Silurian. These Silurian rocks are amongst the most venerable of the aqueous formations on the face of the globe. They have, in fact, the honour of being a part of our earliest Irish land. They extend from the promontary of the Ards Westward, away into Cavan, Southward to near Waterford, and to the East into Wales, Cumberland, and the South of Scotland.

When it is considered that these rocks were originally deposited horizontally, but are now found dipping at all angles, and thrown frequently on their edge, and crumpled up, and bended and contorted, and broken through by faults, and by dykes, and that they were also subjected to the influence of an enormous denudation, eroding them down to probably one-fourth of their original thickness, we shall have some idea of the activity of the forces which were then in operation moulding the surface of our globe ; also, a tolerably correct picture of the appearance which the greater part of the County Down would now have if stripped of its surface covering. It is rather remarkable that, although a North-Easterly trend of the rocks is in some parts observable, and that along the shore of the Belfast Lough the dips—which are sometimes considerable—are all inland, and towards the South, at the Copeland Islands they are all reversed, and towards the North, indicating a deep fault

along the line of the Sound towards Donaghadee. Then there are trap dykes to be found everywhere, some of them quite a study by themselves, inasmuch as the clefts appear to have conveyed from the same regions, at one place the material forming Basalt, at another that forming Crystalline Dolerite, or Greenstone, and at a third Trachyte Porphyry—a peculiar and rare Volcanic rock, said to be unknown in any other part of the British Isles.

It is impossible to estimate with anything like accuracy the thickness of these old Silurians, as there is no visible section in which it can be said the succession is unbroken throughout. It is certain, however, they have a thickness of 7,000 or 8,000 feet. The only fossils which have been obtained are from the dark-coloured shale or slate, which may be found on the coast about half a mile below Donaghadee; also at Ballygowan, Greypoint, Carnalea, and other places. These fossils are chiefly graptolites, and as they are characteristic of the Llandeilo and Caradoc beds of the Lower Silurian rocks of North Wales, there is no difficulty found in referring these County Down rocks to the same series.

The Lead mines of Conlig have long been known. They have been worked with some interruptions, and with varied success for many years. They were abandoned in 1865. It is remarkable that the chief lode coincided with a dyke for nearly one mile, and that some of the lead bearing veins attained a thickness of not less than 10 feet. There is no doubt that, although the carboniferous limestone is more its home, Galena is likely to be met with in other parts of this district. One small seam has recently been stumbled upon at Carnalea. Traces of iron may be seen on the coast below Craigavad, also near Bangor, and crystals of iron pyrites have been picked up near Ballywalter, but not in workable quantity. The surface of beds and joints are frequently found stained with a red hematitic-looking substance, suggestive of iron ore; a probable explanation given of this is that at the period when the Triassic rocks overspread the country, water found its way through the porous sandstone, abstracting some of the peroxyde of iron which forms a small per-centage of that rock, and then percolating along the highly-inclined underlying strata left the deposit as it is now found.

It may be mentioned here that on the coast below Craigavad, the late Mr. Du Noyer lays down some rocks as belonging to the Cam-

brian age; but as he appears to be unsupported in this view, the question must be left for future discussion and investigation.

The Glacial Period, and the peculiar striæ and polish of ice action on some of the exposed rocks at Clandeboye, Groomsport, and Hillsboro' Park, was next reverted to; also, the Boulder clays, Eskers, and Erratic blocks; afterwards—(the reader continued,)—the country appears to have risen gradually to an elevation of some 300 feet above the present sea level. But before this elevation was reached, many pauses appear to have taken place, during which great denudation occurred. This elevation would connect the Isle of Man with England, and raise into dry land the surrounding sea bottom, so that the coast line would extend almost direct from the Mull of Galloway in Scotland to St David's Head in Wales, and Ireland would become connected with England by an isthmus between Carnarvon and Arklow, the deepest part of which is now only 265 feet. A way would thus be made for the passage of the post glacial Mammals and man himself, to pass over. The bed of Belfast Lough would then be a valley over which probably the Cervus Megaceros roamed, and on the slopes, the holly, the hazel, the willow, and the spurge would be found growing luxuriantly. After this various depressions seem to have ensued with long periods of rest. Ample evidence of these elevations and depressions and periods of rest, and of the character of the vegetation, are given in the numerous raised sea beaches and terraces, which are found all along the coast, and in the water-worn caves of our hill sides, also in the submerged forests and peaty deposits which are observed at low tides on the shores of our lough. There seems, therefore, to have been various oscillations of the sea level before the present coast line was established; but there is no certain evidence, that since the dawn of history the present sea level has ever been disturbed.

February 14, 1872.

JOSEPH JOHN MURPHY, Esq., the President of the Society, in the Chair.

A Paper was read by WILLIAM BOTTOMLEY, Esq., entitled—

RECENT EXCAVATIONS IN ROME.

February 14, 1872.

JOSEPH JOHN MURPHY, Esq., the President of the Society, in the Chair.

A Paper was read by Rev. GEORGE MACLOSKIE, M.A., LL.D., entitled—

THE SILICIFIED WOOD OF LOUGH NEAGH, WITH NOTES ON THE STRUCTURE OF CONIFEROUS WOOD.

THE lecturer first referred to the literature of the subject, and stated that references to the petrifications of Lough Neagh appear in authors who lived more than a thousand years ago. It was reported that if a piece of wood were put into the lake, after a certain period, supposed to be seven years, it would be changed partly into stone, whilst the part in the mud became iron, and the part exposed to the air remained in the condition of wood ; or, as tersely versified—

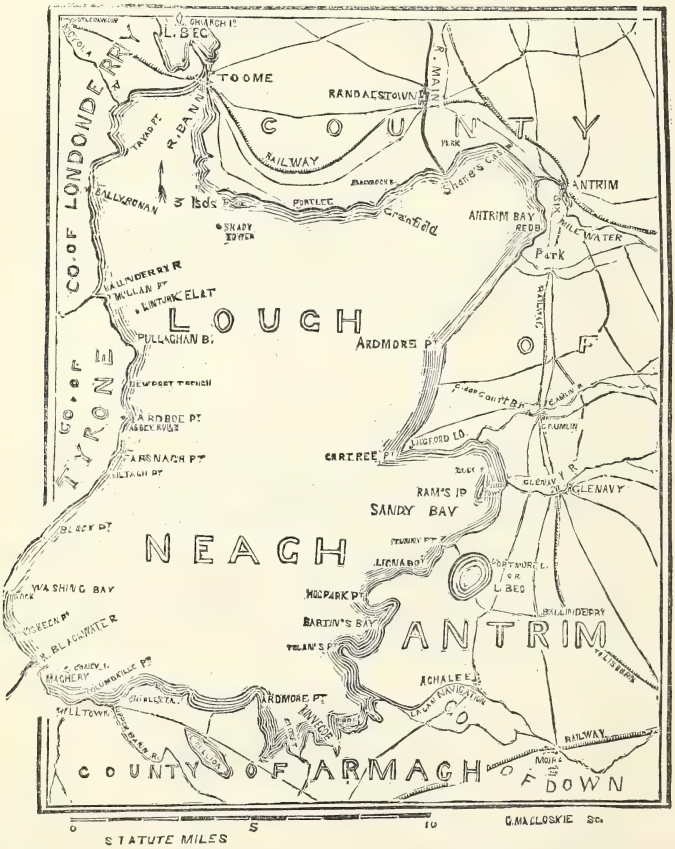
> Est lacus Ultoniæ, Neachum quem nomine dicunt
> Cujus si quivis Aquilentam affigit ad imum,
> In tres septennis species distinguitur annis,
> Pars fundo ferrum, cos fluctibus, arbor aprico.

Along various parts of the shore of the lake fragments of stone are found bearing the aspect and structure of wood, and from the creamy surface of bleached specimens, it was concluded that they had

once been the wood of the holly-tree. In former times whetstones were made out of these, and vended over the country with the hawker's cry—

> "Lough Neagh hones, Lough Neagh hones,
> You put them in sticks, and you take them out stones."

From early times the subject excited the interest of learned men, and towards the close of the seventeenth century the Royal Society had inquiries made to clear up the doubts in which it lay. In 1751, Dr.



MAP OF LOUGH NEAGH.

Barton published his great work on Lough Neagh, which contained an elaborate and reliable investigation of the petrifications. Since his time they have been discussed by Dubourdieu, Scouler, and others; and some light has been cast on them by recent discoveries of plant-remains in the trap-rocks of Antrim and of the Hebrides. The silicified wood is found in the drift deposits at Sandy Bay, to the East of the lough, near Crumlin, and is not confined to the lough shore, but is found far inland in many parts of the country to the East, and Northwards beyond Randalstown; but on the West of the lough it occurs only on the beach, particularly about Black Point in County Tyrone, to which it has been washed by the waves. The plant remains recently discovered near Ballyclare Station of the Northern Counties Railway agree closely with the lignite found on the lough shore near Crumlin, and with the silicified wood. Large silicified trunks have been found under the Camlin River, near Crumlin, and one of these, now at Langford Lodge, is about ten feet high, and as many in girth. Another, which was described by Barton, originally weighed about 700lbs. In certain places near Sandy Bay the silicified wood has been found in connection with lignites, but it is not co-extensive with the lignites, nor does it, like them, occur intercalated between the masses of trap rock. Near Lurgan, wnich is a few miles south of the lake, there is a deposit of lignite, accompanied with silicified wood. Eastward of this we come to the great basaltic district of Antrim and Londonderry, extending over an area of 1,200 miles in the North-east of Ireland, and re-appearing beyond the sea in the Scottish Hebrides and the Färoe Islands. It is necessary to bear in mind that the basaltic plateaux consist of many successive sheets, marking separate volcanic eruptions. * In Antrim the sheets attain the thickness of 900 feet, and in Mull of 3,000 feet; yet these figures do not at all represent their original thickness; as there must have been long and tranquil intervals between the successive outflows of the basalt. Since the last of these outflows, mountains and valleys have been removed by denudation, and new valleys excavated; and the time required for all these changes must have been enormous. We ought also to bear in mind that there occur amongst the basalts intercalated masses of carbonised vegetable matter: such as the coal beds of Skye and

* See Mr. Geikie's article in *Quart. Journ. Geol. Soc.*, Aug., 1871.

Mull, and the leaf beds of Mull; as also the coal beds of County Antrim, and the lignites found at Knocknadona, near Lisburn, at Shane's Castle, and on the Northern Counties Railway, near Templepatrick. At the last mentioned place there were found fragments of branches, with the leaves of coniferous trees, and the leaves of ordinary dicotyledonous trees, as well as those of sedges and grasses. * These plant remains agree very closely with the lignite found on the lough shore near Crumlin, and with the silicified wood. This amount of agreement does not render it certain that all these fossils belong to the same geological formation; but it favours this view, which is confirmed by other considerations. Thus it appears highly probable that all the petrified wood and the lignites, in common with the basalt, are to be referred to the miocene age, like the Bovey Tracey beds of Devonshire, and the corresponding formations in Mull and Skye, as well as the coniferous wood of Eigg.

What yet remains for determination is the stratigraphical relationship of the beds about Sandy Bay, in which the silicified wood found associated with the lignites. That district for a radius of several miles is covered by a thick deposit of boulder clay, resting on trappean rocks. † This boulder clay or drift is of post pliocene age, and contains fragments of basalt and other rocks which have travelled further. It is observed that the clay partakes of the character of the subjacent rock, from which we may infer that if the fossil vegetation belonged originally to the age of the basalts, it would have subsequently found its way through the glacial action of the post pliocene era to the clay beds where it now occurs. The superficial drift contains no shell or other fossil save the silicified wood, with fragments of cretaceous fossils and of chalk. Dr. Dawson, of Montreal, describes ‡ a closely similar drift in Canada, containing drifted pieces of coniferous wood; he supposes the formation to have been deposited by floating icebergs, and accounts for the absence of shells by the supposed rapidity of deposition.

The specimens of silicified wood vary in size, hardness, and in degree of silicification. || When with lignites, they are dark coloured, easily split or crumbling, resembling bog-fir in texture.

* See Mr. Bailey's Paper in *Quart. Journ. Geol. Soc.*, Aug., 1871.

† See *Explanatory Memoirs to accompanying Sheet* 36, of Maps Geol. Surv. Irel.

‡ *Leisure Hour*, 1871, p. 716.

|| See Dr. Scouler's Paper in *Dub. Geol. Journ.* Vol. I.

When long exposed to the atmosphere, or when occurring as boulders in the drift, they are bleached, so that they were thought to be holly; but the internal parts remain black. Even the darker varieties on being burnt become white. Sometimes they consist of a mixture of carbonaceous and silicious matter, and the wood-structure is obsolete. Generally, however, the structure is quite distinct, and when large trunks have been found, the cavities are covered with minute crystals of quartz, "drusy," and sometimes with a layer of chalcedony. Bischov represents a specimen which he analysed as containing 97·71 per cent. of silica, a little peroxide of iron, and not much more than one per cent. of organic matter. * On ignition, an empyreumatic odour was felt, which may be due to resinous matter enclosed in the silicified fibre.

A microscopic examination shews that the delicate structure of wood is still retained, but instead of being holly, it is the wood of coniferous trees, as is proved by the rounded disks in the wood cells. Barton made a close guess when, judging from the smell, he set it down as cedar wood. The *coniferæ* do not seem to have been the only trees living at the particular time and place to which they belonged, for leaves of alder and beech, and of other ordinary exogenous trees, as well as of coniferæ, have been recently found at Sandy Bay by Mr. M'Henry, of the Geological Survey. Dr. Carpenter states that the wood of coniferæ, palms, and arborescent cryptogams is preserved where the harder wood of oak, elm, and beech decays. † The British miocene flora was very luxuriant, having evergreens like the fig, evergreen oak, custard apples, vines, with palm trees, and ferns, and the coniferous sequoia, a tree as large as the *Wellingtonia* of California. That was an age of warmth in Northern regions; and we may have in the silicified fossils the only representatives of a rich and varied vegetation. The wood of *Coniferæ* is remarkable for the absence of vessels or ducts, and for having tubular wood-cells covered by rows of circular disks on the sides facing the medullary rays; whilst the medullary rays themselves bear smaller disks. By these characters we are able to recognise small pieces of this kind of wood. Our figures (1 to 5) represent the different sections of the wood of the common

* Dr. Hodges states that he found a much larger proportion of organic matter present, perhaps 20 per cent.

† *Vegetable Physiology*, § 861.

deal *(Pinus Strobus)*. Fig. 1 represents the sides, and fig. 2 the

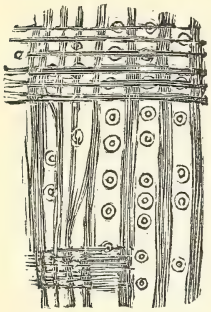


FIG. 1.

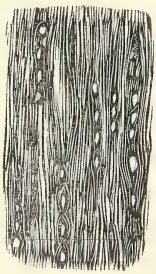


FIG. 2

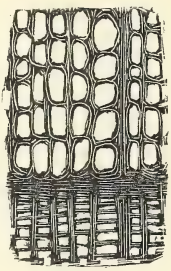


FIG. 3.

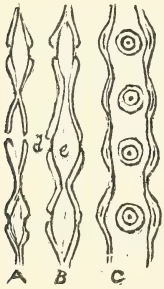


FIG. 4.

FIG. 5.

view in the direction of the radius of the longitudinal sections of the disk-bearing wood cells. Fig. 3 represents the transverse section, when we look down into the tubes of the long cells. They appear crowded densely together at the autumn growth, so as to mark the boundaries of the growths of two successive years. Fig. 4 and 5 represent the disks of fig. 1 still further magnified. Fig. 6 represents the duct of a non-coniferous plant (the common lime tree), and is given for the sake of comparison. The white spots in Fig. 2 mark the ends of the medullary rays which appear passing out from one to another.

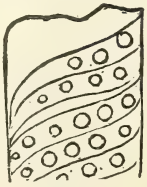


FIG. 6.

There are two leading divisions of coniferous wood—

(1) the *Pine* division, where the disks are usually *detached* and in *single* rows, or if the rows are double the disks stand opposite to each other. Figs. 1 to 5 represent this division, as also does the wood of juniper, fig. 7 (*juniperus communis L.*)

(2) The *Araucarian* division, in which the disks are in *single*, *double*, or *triple* rows, those in one row *alternating* with those of its neighbour. Where there is a single row, the disks are in *contact* with each other. When in triple rows they are crowded, and those

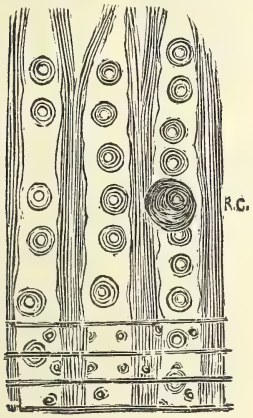


FIG. 7.

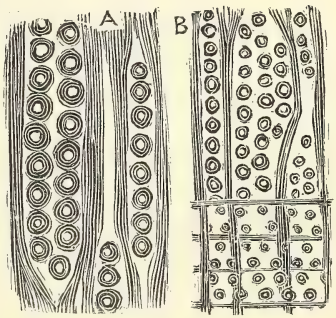


FIG. 8.

in the centre row are perfect hexagons, from pressure. Fig. 8 (where A represents the *Dammera alba*, and B the *Araucaria* (*Eutassa*) *excelsa*, illustrates this division. In other kinds we find peculiarities; thus in *Taxus*, or Yew, there are spiral fibres in addition to large bordered pores, as in figs. 9, 10, 11.*

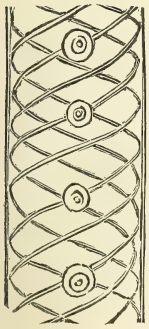


FIG. 9

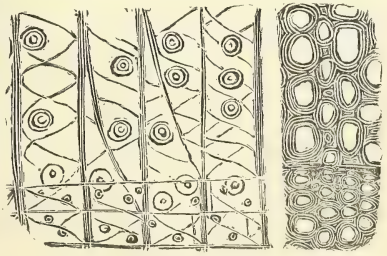


FIG. 10.

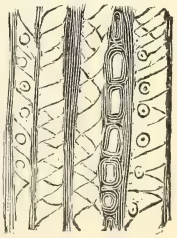


FIG. 11.

* Fig. 9 is copied from *Catal. Histol. Series. Mus. Coll. Surgeons* (England) where, as also in *Queckett's Histology*, it is erroneously referred to *Araucaria*.

Cycas revoluta has bordered pores, each with a slit-like marking in the centre. The structure of *Taxodium* (fig. 12) is somewhat similar ; where the concurrence of two slits on the opposite sides of a

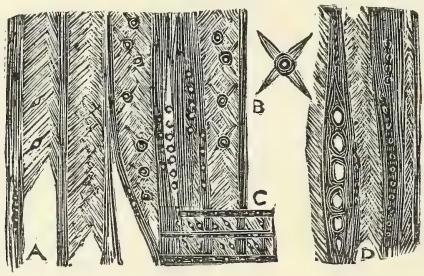


FIG. 12.

tube-cell gives the appearance of a cross, as at B. D represents the tangential section, with the ends of the medullary rays, as in fig. 2. *Ephedra* has disks without the central dot. In some instances there are no disks. Further distinctions are got from the presence or absence of resiniferous cells, or ducts.

The nature of these pores or disks has been a subject of controversy. They have been variously deemed glands, or tumours with holes to secrete turpentine, or spots in the cell-wall, or as disks with perforated centres. Mohl discovered them to be circular spaces, their thinnest parts being placed opposite each other, giving lens-shaped cavities

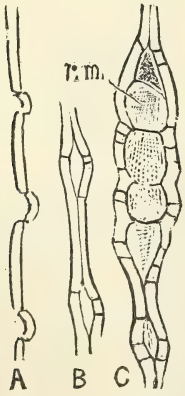


FIG. 13.

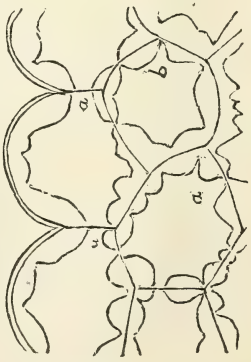


FIG. 14.

between the adjoining wood-cells, as seen in figs. 4 and 13. Fig. 14 gives a transverse section of the wood tubes, with the matter of lignification separate on one side from the elementary membrane. At *aa* appear the pits on corresponding parts of adjoining cells; at *b* one appears without any corresponding one. Fig. 15 A is a section of two tube-cells, showing lens-shaped interspaces on opposite sides.

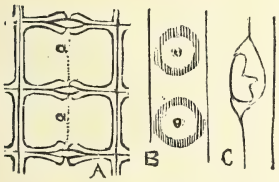


FIG. 15.

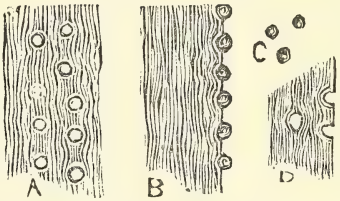


FIG. 16.

Light passses in the direction of *aa*, and is decomposed so as to present varying colours. C in this figure, as well as fig. 5, shows the centre of the disks when seen in profile to bulge out. B represents two young disks. Fig. 16 represents silicified wood from Fredericksburg, in Virginia, showing at B small globular bodies, seen again detached at C; at A and D are the empty intercellular cavities which contained them.

Thus the disks consist of depressions in contiguous fibres, enclosing cavities, which may become filled up with intercellular matter. The thin wall in the centre is perhaps capable of distension according to the varying pressure of the enclosed gases. Schleiden thought they arose from spiral fibres in the young wood; but at fig. 15, B, the young disks appear as tumours with a central pit. The cells of the medullary rays also bear disks, which are much smaller than those of the wood-cells. From a consideration of the absence of these vessels or ducts in the wood of these trees, so that the ordinary wood-cells discharge the functions which are elsewhere shared between various kinds of vessels; of the absence of hard deposits in the wood-cells, which are thus long tubes; of the presence of spiral fibres in some cases to keep the tubes distended; of the intimate connection between the vertical and horizontal growth, as evidenced by the medullary rays having disks in imitation of the wood-cells; of the close correspondence in position between the disks of adjoining

wood-cells ; and finally from a regard to the habits of these trees, as tall, evergreen, rapidly growing trees, and as manifesting much circular uniformity in their growth, we may conjecture the functions which the disks perform. Easy communication is required in all directions through the trunks. The ascending sap has the long tubular cells to conduct it, and these tubes give passage to gases as well as liquids ; the descending sap passes inwards by the soft and tubular medullary rays. The disks of the wood-cells aid in giving an easy passage round the stem to the fluids and gases ; the leathery walls of these wood cells would not allow the diffusion of the sap or gases in the circumferential direction ; but as in other trees we have ducts with transparent walls, so we have here much of the wall on each side of the wood-cell reduced to the thin membranes of the disks. Of the three channels of communication, the vertical is the most active, next is the radial, and last is the circular. It is known that the relative conductivity for heat possessed by wood varies in the same order.

It easy to assign any fragment of wood to the coniferous class where we can detect these disks under the microscope. But when we come to inquire into the proper subdivision our difficulties increase. We have already considered the characters which mark the two leading divisions of this wood, and we have noticed subordinate peculiarities. Some writers have established genera and species of fossil coniferous wood, denominating all that resemble Pine as *Pinites*, and all that resemble Araucaria as *Araucarites* : various specific marks have been derived from the character of the annual rings, the character of the cell walls, the arrangement of the medullary rays, and the abundance or rarity of resiniferous cells or ducts. Thus the Lough Neagh silicified wood is named by Kraus *Cupressoxylon Pritchardi ;* the genus *Cupressoxylon* is described as "Wood having narrow, distinct, concentric layers. Prosenchymatous cells porous, the pores large, round, in one or more series, opposite. Resiniferous cells very frequent. No resiniferous ducts. Simple medullary rays."

This group is represented by Cupressaceæ and Podocarpeæ of living coniferæ. It resembles Cedroxylon, being distinguished from it by having resiniferous cells, whilst cedar wood has resiniferous ducts. The *species* is characterised as having concentric layers of wood not very conspicuous, wood cells thin walled, narrowing towards

the boundary of the layer, disks in one or two series, minute, contiguous; medullary rays simple, rarely compounded, of 1 to 25 cellules of large size; copious resiniferous ducts. Its only known locality is Lough Neagh.

As has been shown by *Schimper (Traitè de Paléontologie Végétale*, Paris, 1870), these distinctions are not to be relied on. For the genus *Pinus* alone can we get specific characters, and in other cases we must dismiss specific and generic distinctions. The wood called *Araucarites* is not necessarily the wood of Araucaria, but may belong to Walchia or some other genus, and the Lough Neagh silicified wood, though called *Cupressoxylon* does not necessarily belong to Cypress. Kraus has arranged all the varieties of coniferous wood into five typical groups :—

1.—Type of the Cupressaceæ (Cupressoxylon), comprehending Cupressaceæ, Podocarpeæ, and part of the Taxaceæ.

2.—Type of the Abietaceæ (Cedroxylon), including the genera Abies, Picea, Larix, Cedrus.

3.—Type of the Pines (Pityoxylon) including the genus Pinus and its subgenera.

4.—Type of the Araucaria (Araucarioxylon) including Araucaria, Dammera, and some extinct forms.

5.—Type of the Taxaceæ (Taxoxylon) including all the genera of Taxaceæ not included in type 1.

The first of these types, the Cupressoxylon, includes the Lough Neagh petrified wood, which may thus be regarded as representing some tree whose wood agreed with that of the Cypress. The tribe of the Abietaceæ took the lead in the Tertiary European flora; whilst the Cupressaceæ occupy the second place. The *Sequoia* is intermediate between these orders, and attained its maximum during the miocene age, abounding even in the Arctic regions. As remains of it have been found in the Antrim basalts, and at Sandy Bay, our specimen may belong to it. Now it is confined to a strip of land beyond the Rocky Mountains of North America. It is probable that Europe possessed no species of Cupressoxylon during the pliocene or post pliocene age, so that we are thus driven back to the miocene for the origin of the specimens found in the boulder clay.

Fig. 19 represents the silicified *Cupressoxylon Pritchardi* of Lough Neagh. It will be observed to have a close resemblance to the wood of the common juniper (fig. 7) and pine (fig. 1). *

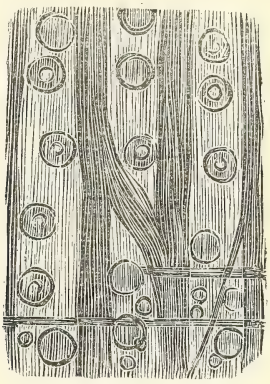


Fig. 19.

As to the nature of the process of silicification, two different processes are popularly confounded under the term ; (1) the incrusting process, as at the geysers of Iceland. This is simply a deposition of silica from surcharged water, especially on its evaporation. Complete evaporation of the water is perhaps necessary, and hot water is favourable to the process. (2) Interstitial silicification, where the organic matter is removed particle by particle, the delicate internal structure of the original organism being usually preserved. The Lough Neagh wood has undergone the second kind, or interstitial

* We append a translation of Schimper's definition of the types of coniferous wood, or as they are sometimes denominated, genera.

A. Prosenchymatous cells *devoid of pores*, *Aporoxylon*, Ung.

B. Prosenchymatous cells *bearing pores*.

I. Pores *uniserial and distant, or opposite*.

a. Prosenchymatous cells *porous, without spirals*.

1. Parenchymatous (resiniferous) cells absent.

a. Cells of medullary ray *circular* on a transverse section, *Physematopitys*, Goepp.

b. Cells of medullary ray *oblong* on a transverse section, *Cedroxylon*, Kraus (*Pinites* Goepp, *Peuce*, Ung. ex p.

2. Parenchymatous (resiniferous) cells very numerous ; *Cupressoxylon*, Kr. (*Cupressinoxylon*, G., *Thuioxylon*, Ung.)

3. Parenchymatous cells numerous ; resiniferous ducts present. *Pityoxylon*, Kr (*Pinites*, G., *Peuce*, Ung. ex. p.)

b. Prosenchymatous cells *porous with spirals*.

1. Medullary rays *porous*. *Taxoxylon*, Kr. (*Taxites* G., *Taxoxylon*, Ung. ex. p.)

2. Medullary rays *porous*, with spirals. *Spiropitys*, G.

II. Pores *uniserial* and *contiguous*, or *pluriserial* and *spirally arranged*.

a. Pores *round* or polygonal from contact.

1. Medullary rays *simple* (uniserial) Araucaroxylon, Kr. (*Araucarites*, G., *Dadoxylon*, Endl.)

2. Medullary rays *compound Pissadendron*, Endl. (*Palæoxylon* Brongt ?)

b. Pores *compressed, oblong, Protopitys*, Goepp.

silicification. The process must have been caused by water containing silica in solution, but it was not due to the water of Lough Neagh, as that water is singularly free from earthy constituents, and is not known even to have any tendency towards silicification, and the lough did not exist as such at the time when the process took place. Nor can the adjoining soil or clay have produced any such effect, as it is only when dissolved in water that the silica can penetrate the structure of wood. Nor can the agent have been hot water or steam, as has been supposed in some quarters, for it would in this case have reduced the ligneous matter to a pulp, and destroyed it. The water of rivers at ordinary temperatures has in many instances produced such a phenomenon, even within the historical period, silicifying wood to a greater or less depth from the surface, and several illustrative cases, from the Danube, from a river of Saxony, from Egypt, and from America, are given in *Bischov's Chemical Geology*. The waters of most rivers and of the sea contain a very small percentage of silica, which is sufficient to supply material for the process. Bischov lays down the rule that the less soluble material replaces the more soluble in these circumstances. It is usually found that the change commences at the surface, so that the internal parts remain longest unsilicified, and often decay, whilst the outer shell becomes hard and stony, and subsequently the internal parts may become filled up with a foreign matter, as sand. Soft wood may be most easily preserved, as the silicifying process will here most rapidly penetrate to the heart of the trunk before it has time to rot. Thus the silicified wood is usually hardest at the circumference, and softer in the centre.

Hence we may sum up our observations by stating that—

(1) The petrified wood under examination represents what were once living trees, from which most of the organic matter has been removed, and replaced by silica.

(2.) The original wood was coniferous, of the type Cupressoxylon; and may have been of the genus *Sequoia*, but this is uncertain.

(3.) There is an intimate connection between this silicified wood and the lignites of Antrim. It is never found in conjunction with the lignites in the basalt, but it is found with those in the boulder clay, and a comparison of the two groups of lignites with each other and with the silicified wood is in favour of the view that the latter is a representation of miocene vegetation.

(4.) The process of silicification is probably due to cold water holding silica in solution, as it often occurs in the water of running rivers. The time required for transmutation must have been very great, many hundreds of years at least, but not necessarily greater than periods which are grasped in history.

(5.) The notions that the change takes place in seven years, that the wood changed is holly, and that the silicifying agent is the water of the lake are erroneous; as are also the opinions that the wood was araucarian, that the change was due to the soil of the adjoining country, that such process is still in progress, or that it was caused by the agency of hot water or steam, charged with silica.

(6.) The geological age to which it is due may be fairly conjectured. It is found in post-pliocene clay, to which it was transferred, after silicification, from its original bed. The connection with the lignites, as well as the structure of the wood, and the comparison of successive tertiary floras, point to the *miocene* as to its original date. The fact that only the one kind of wood occurs in a silicified condition does not imply that it was the only tree existing at the time in its habitat.

(7.) A consideration of the circumstances under which silicification takes place may help us in picturing the state of things in which this wood was silicified.

A rapidly-flowing river, containing silica in solution, and having logs of trees in its channels, would afford favourable conditions for the production of silicified wood, and we may thus guess at the origin of that for which the neighbourhood of Lough Neagh is celebrated. The Antrim system of trap-rocks forms part of a more extensive system, which includes the Hebrides, much of Scotland, and islands North of Scotland. All this district during the Miocene age constituted part of a continuous continent. Its Northern parts were occupied by mountains covered with luxuriant forests, and watered by large rivers. Mr. Geikie has recently discovered the bed of one of these rivers under the Scurr of Eigg, one of the Hebrides; and fragments of coniferous wood have been found there which Lindley and Hutton call *Pinites*, and which has been silicified like that of Lough Neagh, but which belongs to a different coniferous type. In the island of Mull silicified wood has been found, agreeing substantially in external characters with that which we are describing; in fact, the

elaborate description of it which Mr. Nicol gave forty years ago would apply in every word to the Lough Neagh specimens. Many rivers must have flowed southward over the basaltic continent of the Miocene age, and we may possibly find an explanation of the petrifying process by supposing the petrified logs to have grown as forest trees in the mountains North-west of Scotland. Lignite beds were formed by swamps, and masses of lignite would be transported by floods. Logs of trees might be silicified in such rivers, and some of these be buried up under subsequent outflows of basalt. Then the glacial action of the post pliocene age may have transported some, the original locality of which may have been since destroyed by denudation, to the Neagh district, wearing and rounding them, and at last leaving them in its clay-drift. This is only a fancy picture, but it is the best attempt we can make to realize the conditions under which these remarkable fossils may have been deposited,*

* Through the kindness of my friend, Mr. William Gray, I have lately seen a specimen of partially silicified lignite, which was obtained intercolated between the beds of trap at Lawrencetown, near Banbridge. This is, I believe, the first instance of intercolated lignites in the Antrim basalts being found in a silicified condition; and it confirms the conclusions suggested above.

February 21, 1872.

JOSEPH JOHN MURPHY, ESQ., the President of the Society, in the Chair.

A Paper was read by THOMAS M. LINDSAY, Esq., Head Master of the School of Art, Belfast, entitled—

EGYPTIAN ART.

THE author proceeded to say that he did not pretend to the "learning of the Egyptians," but would limit himself to that branch with which his studies had made him tolerably acquainted—viz., architecture, painting, and sculpture, and ornamental art generally, approaching the subject from a strictly artistic point of view. He, however, would notice such well-authenticated evidences of the institutions of the country as would be necesssary to account for the production of the peculiar classes of art workmanship. After enumerating some of the causes which had attracted to Egypt scholars, archæologists, and the travellers "who wield the graphic pen of the pleasant scribe," and paying a tribute to the books and illustrations we possess, the lecturer stated, that while the largest portion of the noblest monuments of the land belonged to a period contemporary with the patriarchs, others of great magnitude and interest were executed after the invasion by Cambyses, the Persian. Egypt was an instance in which the conquerors by physical power have yielded to the moral or religious force of the vanquished, uniting men by bonds far more potent, though apparently deficient in the rude strength by which their own body politic had been held together. Another instance was the Norman invasion of England, after which the conquerors adopted the language of the Saxons, and, to a great extent, their habits and institutions. The lecturer would not speak

of the Pyramids, which were rather works of the engineer, and did not invite artistic comment. Besides, the subject had been ably treated already by Mr. Wild, of the Academical Institution, and by the Earl of Dufferin. It was to the temples and tombs that he would direct their attention, those abounding treasures, where there was no occasion to trace the arts in their meagre origin, but where we find their highest development in a perfect "petrifaction of style." In the works of all other nations we find a certain development from the rudimentary forms to some culminating point, but in Egyptian art we come at once upon the maturity of their ideas, the perfection of their power. The remains of Egyptian art are of a purely monumental character. If we apply the standards of later and more favoured styles, the refinement, symmetry, and beautiful proportions of the Greek; the slenderness, loftiness, the heaven-aspiring lines of the Gothic, or the rare examples of happy combinations of brick and stone of our own days, we cannot but be prejudiced against the low proportions, the horizontal masses, and the simple, childlike means of construction of Egyptian architecture. At first glance there arises a feeling that it is utterly devoid of beauty, though we may wonder at its ponderous massiveness, its Titanic grandeur, and uncouth sublimity. When, however, the first impression wears off, when the eye, becoming accustomed to the gigantic, assents to its peculiar grandeur, that which appears low and unwieldy from other standards, seems admirably appropriate in the Egyptian landscape. The horizontal masses prove delightful to the eye, the great broad shadows which they cast suggesting coolness and repose; and their gay, many coloured decorations, by contrast, appear to temper and modify the dazzling palpitating brilliance of the surrounding sunshine. There would also be found, upon a closer examination, much elegance in many of the forms employed, and the evidence of powerful legitimate architectural effect; and many of the details were invested with considerable refinement aud beauty.

But whatever the merits of Egyptian architecture and its adaptation to the wants and conditions it was associated with, it is scarcely of service in these times; and the erection of a palace in the Egyptian style, by a prince of the nineteenth century, (Prince Napoleon,) was a case for a commission of lunacy. The large spinning mill of Messrs. Marshall at Leeds—modelled on the temple of Denderah—

was less objectionable, its object being to obtain a room of very large area, lighted from above, and covered by a flat roof.

The architecture of Egypt seems evidently to have been borrowed from wooden originals. Props and beams used in the first construction are now imitated in stone. The lintels of the doorway remain rounded, and the walls are like timbers grooved and jointed together. The slope of the walls is another evidence, and the bold cornice suggests projecting ends of beams to obtain a deeply cast shadow—an excellent artistic device. The architrave was doubtless used in place of the former main beam. The columns also evidence wooden originals; most of them represent either a single papyrus stem or a bundle of them. The plans of the Egyptian temples could be traced in their various changes or developments. First, the sacred edifice was a mere square or oblong chamber with single entrance, sufficient for their earlier and more simple religious ceremonies. Then came the addition of an ante-room with portico, and two or more pillars standing between the projecting walls. Curtains of stone were carried half-way up the front to complete the additional room. Afterwards other courts were added, some closed, others open to the sky with cloisters, or with avenues of sphinxes, and planted with trees constituting the sacred grove, or Temenos. A huge structure, forming a gateway or pylon, was also added, besides obelisks and statues. The temple contained all that was most precious in the nation's eyes; it was the dwelling place of the king and priests; it contained the statues of their gods, the valuable gold and silver utensils of ceremony or worship, and was the Royal Treasury. The temples were used as forts, and the "hundred gates as sung by Homer" were not the city entrances, but those of the numerous temples.

Egyptian art is essentially symbolic, the various forms having been taken from nature; not copied imitatively, but suggested in character; conventionalized, not realistic; made solid looking, not as though they could be plucked. The columns may be classed under five heads—1st. The square or octangular. 2nd. The bud capital. 3rd. The bell capital, with fully-blown lotus flower, or a cluster of palm branches. 4th. The Isis-headed capital. The 5th has a figure attached, either a king, a god, or a monster. These several orders were often commingled. Besides these, two other capitals, with horns or volutes, have been found in the bas-reliefs. Our interest in their architecture

is increased by the knowledge that the Greeks adopted many of their essential forms, which, however, they developed and surpassed in elegance and application. We can easily understand how this quick-witted nation, in its infancy, borrowed of the Egyptians, then the dominant race, and, as such, likely to lead the fashions. Egyptian architecture relies for much of its effect upon the colour with which it is invested. The flat tints with which every detail and space were picked out, appear in many cases as fresh and vivid as when they were first spread on. The lecturer then drew attention to the drawings of the temple of Denderah, it being the most perfectly preserved example of the highest type of Egyptian architecture. He then explained the plan, dimensions (136 feet x 78 feet x 68 feet high), and the mode of lighting, the effect of which was to make it perfectly cavernous, dim, and awe-inspiring, and well calculated to impress the worshippers. The ornament employed is quite barbaric in its richness and material splendour, the sculptures having alike escaped iconoclasts and Arabs. Egypt seems to stand alone in this respect, that all her relics, like her mummies, are well preserved ; while other great nations of antiquity have left us little besides the skeletons of their former grandeur. The walls of Babylon and Rome were as nothing compared to these huge masses and flat uncompromising surfaces which were raised to last as the very pillars of earth — tranquil, stable, eternal.

Sculpture was the great ally of architecture, and no way inferior in magnitude and a sense of power. Sculpture was never intended to be isolated, to be viewed from all points as that of modern times. The statues were used chiefly to mark the entrances of buildings. The great sphinx and the twin colossi on the plain of Thebes are, perhaps, the largest stone carvings ever attempted. Another feeling of interest which attaches itself to many works is the use of valuable and durable materials, as granite and basalt, which are likewise the most intractable of all stones. The pitch of delicacy and minuteness to which the carving was carried is wonderful. Considerable knowledge, if not severe accuracy, of anatomy, is also shown in the statues. The muscles, though soft and pulpy-looking, are always correctly indicated. The expression is often benign, and at times almost humorous. After the conquest of Egypt by Cambyses, sculpture, like architecture, began to reflect some of the advances made by Greece in the arts. A great

change, however, was inaugurated with the Roman occupation, when artists contented themselves with imitating primitive works. If it be true that art is essentially the reflection of the character and life of a people, the sculpture of the Egyptians exactly typifies the unprogressive and artificial state of their forced existences and institutions. The arts were practised under a depotism of traditionary canons. The priests alone knew the meaning of the works, and the fetish-like characters with which they were invested. The craftsmen were mere machines, performing their tasks without venturing beyond the prescribed bounds. Their minds were consequently cramped, ignorant, and superstitious. The scheme was that of a schoolboy, the work was one of giants. The lecturer then carefully analyzed the various drawings and photographs of Egyptian sculpture. Every limb was immovable, and the faces blank and impenetrable. There is neither energy, thought, nor vitality represented, and yet, with all its drawbacks, there are not wanting evidences that if these arbitrary laws had been withheld, works might have been produced to rival those of later nations.

Arguing from the analogy offered to us by the progress of other nations, painting must have originally preceded sculpture, but the painting of the Egyptians, with which we are acquainted, sprung naturally out of their carvings in low relief, the shallowness of which required colour to mark them more distinctly. The lecturer then explained the system of proportions which they adopted for the human figure, and the methods pursued in producing the wall pictures and hieroglyphics, as detailed by Mr. Owen Jones. The colours employed were red, yellow, green, and two tints of blue. Black was also used, and the plaster ground served for white. The colours were mixed with dissolved glue, and sometimes even with wax. They were laid on in flat patches, singly and unmixed, except in the case of green. This very limitation of colours conduced to the excellent effects obtained, because red, yellow, and blue constitute perfect harmony; the fewness of pigments causing the use of the whole list. The panel portraits add another of the many proofs of Egypt being the cradle of various branches of knowledge, developed and perfected by other nations. But there is no advance upon the wall pictures. There is still the same formality of expression, rigid outlines and flat tints, with as much individuality of features as on the mummy cases themselves,

raising no regret that we were unacquainted with the illustrious deceased. In the paintings of the Egyptians there is never any notion of perspective expressed, neither landscape, distance nor foreshortening. If a figure is to be represented beyond others it is placed on a shelf above them. Multitudes, collections of buildings, or masses of figures are therefore seldom, if ever, attempted. But the art was essentially historical, better entitled, perhaps, to that designation than the pictures produced now a-days, with a telling—and a selling—subject from Hume and Smollet. The Egyptian artist was a real pre-Raphaelite, and we must admit that in representing animal life he becomes lively and spirited. The monkey is drawn with characteristic impishness, and the pig, though under a ban, was as capricious and roguish as any curley tailed grunter in Ulster.

All the most important tombs are excavated out of the living rock, the architectural features being exact copies of the ordinary buildings, only more or less modified to suit new necessities. The necropolis at Thebes is a vast assemblage of tombs, where many of the most illustrious kings have been buried. There are innumerable smaller erected sepulchres arranged round the pyramids. The tomb was proceeded with only during the king's lifetime, and its state of completeness determines the extent and magnificence of his reign. In the tombs we find a history of the nation's social life; their habits, customs, and occupations; gossip, conceit, envy, and curiosity; games of all sort, feasting, with its accompaniments of music and dancing; the pleasures of the life generally, and the excesses of the table. It would seem as if all the phases of social existence in our own time find their beginning here.

The paintings on the temples were considered as national records, relating to the rites and ceremonies of religion, the exaltation of kings; they showed the images of their gods, and the magnificence with which conquerors celebrated their triumphs; and how they made abject slaves of their enemies. The more illustrious the personage the larger becomes his representation. All their ornamental forms were symbolical, and taken from nature. The lotus and papyrus symbolize the food for body and mind; the wings and feathers of birds were emblems of sovereignty; the palm branch suggested fertility; the snake denotes royalty; Scarabæi indicated blessing or good luck; the globe, like the Teuton ring, signified eternity, &c. Many of the simple forms,

as the fret, the zig-zag, the wave scroll, the chequer, and others, were suggested by weaving and plaiting. These are a few of the types which formed the basis for an immense variety of ornament decorating alike the jewel casket of the queen, or the sarcophagus, which enclosed the last remains of that person which it was once her pride to adorn.

The tombs were often the depositories of domestic utensils, weapons, furniture, dress, glass, porcelain, earthenware, &c. The relics have been purloined alike by thieves and antiquarians from the time of the Greeks. All the forms of service are admirably adapted to fulfil the office for which they were intended, and are decorated in the most appropriate manner. (The lecturer then took a series of shapes, and pointed out how exactly they were suited to their requirements.) The furniture was always wrought in graceful lines and good proportions, and the construction springing out of the natural requirements is simple, workmanlike, and satisfactory to the eye. They were acquainted with veneering, and inlaying of various kinds, panelling, and dovetailing. They worked in a variety of choice and hard woods as well as ivory. It is remarkable that, in many customs, they resemble Europeans rather than the orientals of the present day. They sat at meals. Though the chairs of state were very upright, others were comfortable and graceful. Carpets and rugs, often used in the cooler weather, were invested with beautiful patterns, in vivid, harmonious colours. Embroidery and the use of gold thread were known. Dyeing was practised. Though the linen and cotton machinery was of the rudest description, the specimens found, rival in fineness and finish our own manufactures. The working and compounding of metals was known at a very early age. Vases, statuettes, mirrors, weapons, and instruments have been left in large quantities. Allusion is made in "Exodus" to "jewels in silver and gold." They practised chasing, engraving, and punching; also, inlaying with precious stones, and enamelling. Their gilding upon wood and bronze was very durable. The toys are invested with peculiar interest, they are that "touch of Nature" which vibrates the chord of our common humanity. A drawing of one of the dolls shows it to have been well carved, and jointed in the style of the well-known Dutch dolls. "It wants the arm, but what matter? shows us the life of Egypt in another phase than as that of mystery

and tombs. These people were, after all, human, * * * * and, in the light of this simple object, the dim centuries seem to pass away from between, and we see the little Egyptian maid fondling her cherished doll, and—who knows?—crying, perhaps, bitter tears for the loss of the arm torn off by some rough playfellow."

The conditions under which the fine arts flourish are not easily defined. In Greece the noblest monuments of the land sprang into existence with the varying opinions of a Republic. In Rome a large demand for the productions of the artist, through all the revolutions of twenty centuries, has never ceased to prevail. The various phases of art have shone under the most varying and even opposite conditions; but it would not be very difficult, in the form of art production characteristic of any period, to discover some indication of the prevailing religious, political, and social influences under which it was produced. The genius of the architect, sculptor, and painter, through centuries, erected noble cathedrals, filled niches with prayerful images of the apostles; made churches more attractive with pictures of the Madonna, saints, and martyrs, and incidents sacred to the common belief; so that we are bound to acknowledge that the religious idea animated in greater or less degree the chief designer as well as the humblest craftsman. The rivalries of Popes, Cardinals, and Princes encouraged the exercise of originality, and stimulated ambition; while the varied scenes of study imparted breadth to their ideas, and fostered individual power. Reflecting the light we thus gather upon the Egyptian architecture, sculpture, and painting, we may find a clue to its high excellence and unchanging character. It must have taken centuries to allow of the growth of the luxurious tastes and complicated refinements and appliances those tastes called forth; and for the germ of the religious idea to spring, perchance out of some wretched fetish worship, and in time to overshadow the land. The people suffered from the great wars of which the paintings have left us such cruel records. The millions toiled, obeyed, and suffered. But in the intervals of peace they must have raised abundance from the fertile land, and had comparative exemption from oppression to enable them to yield tribute to maintain temples, palaces, and the retinues attached to them. The representation of their gods and the symbols gradually settled into a fixed type, and was so maintained by the hereditary priesthood, lest any change might lead to sophistication in the

idea symbolised. The art work of the Egyptians suggested, as already shown, many ideas to the Greeks, and even our cabinetmakers have condescended to borrow the patterns of chair or couch in which, perhaps, Sesostris sat in state, or the priests of Luxor took their afternoon siesta. Our study, too, has also confirmed the impression that wealth must exist and be accumulated to afford inducement for large bodies of people to devote themselves to artistic work; that such accumulations must not be subject to frequent dispersions; and that all art work, to possess intrinsic merit, must minister to usefulness and fitness, or to the expression of some dominant idea. But if this dominant idea imposes restraints on the healthy exercise of the imagination, and sets up a barrier on its devious upright path, inscribed "Thus far shall thou go and no farther," it checks the vitality of art, dooms it to stagnation, inevitable degradation, and certain decay.

The paper was illustrated by upwards of forty coloured diagrams prepared by the pupils of the Belfast school of art.

March 13, 1871.

Dr. James Thomson, the Vice-President of the Society, in the Chair.

A Paper was read by Joseph John Murphy, F.G.S., President of the Society, entitled—

The Bernina Lakes.

These two little lakes are situated on the summit level of the Bernina Pass, which leads from the valley of the Inn, near its source in Switzerland, into the valley of the Adda in Italy. They are about 7,700 feet above the level of the sea. There is a little vegetation around them but no trees. They are separated by a stony bank, evidently the moraine, or mound of rubbish, brought down by an ancient glacier now extinct. This bank constitutes the water-shed of the pass; the water of the larger of the two lakes flows into the Adda, and that of the smaller one into the Inn.

What is remarkable about these lakes is their colours. The smaller is dark blue, an unusual colour among Alpine lakes, which are generally greenish; the larger is whitish when near, but when seen from a distance it is of a lighter green than any other Alpine lake known to the writer; so that these two lakes have the remarkable distinction of being one of them the lightest in colour, and the other the darkest, of Alpine waters. Their colours make them a very remarkable object in the panoramic view from the Pitz Languard, a high mountain which is ascended from Pontesina.

The cause of the light colour of the larger lake is obviously the mud brought into it by the glacier streams which feed it; and the reason of the dark colour of the smaller lake is the purity of its water; for it receives little or no water except that which filters through the porous bank by which it is separated from the other

lake. It has been shown by Dr. Tyndall's observations on sea-water, reported in the *Fortnightly Review*, for March, 1871, that the green and blue colours of the sea depend on the solid matter it contains in suspension, very finely divided though not dissolved. The less it contains of this foreign matter the darker it is, and if it were absolutely pure, it would no doubt appear black when seen from above. Of course the same explanation applies to the colours of Alpine lakes.

On the Same Evening, Dr. JAMES THOMSON showed in operation, and gave an explanation of the "CALCULATING MACHINE" of M. THOMAS, of Colmar.

March 20, 1872.

Joseph John Murphy, Esq., the President of the Society, in the Chair.

A Paper was read by HIRAM SHAW WILKINSON, A.M., entitled—

Political and Social Revolutions in Japan.

The lecturer commenced by giving an account of the constitution of Japan at the time of the opening of that country to foreigners; of the changes which it has since undergone, and of the influence of those changes on the foreign relations of the country, and on the social condition of the people. He then referred to the political parties in Japan, in the order of time with which foreigners had to deal, namely, the Shogun or Tycoon, and his government; the Damios, or territorial nobles, and their retainers; and the Mikado, or emperor, and the nobles of his court. Of these, the Mikados deserve our first notice, on account of their exalted rank, and of their ancient lineage. The genealogy of the Mikados has been traced by the Japanese chroniclers beyond the time of authenticated history—far back into the region of myth and fable, through gods and goddesses, till it arrives at length at the Deity, which appeared at the first evolution of order out of chaos. Their conception of this Deity is not of a great pre-existent order. The lecturer then went on, at great length, to explain how an insurrection arose out of differences between the Tycoon and his subjects regarding the introduction of foreigners

into his dominions, which resulted in his overthrow and death, and how a young Mikado ascended the throne, when peace was again restored, and commerce with nations encouraged and protected. In speaking about the Tycoon's successor, he said that it was not by his own right arm that he had gotten himself the victory; his youth indeed would have been sufficient to prevent him taking an active part, for he was yet a minor. But it was no longer possible that he should be reduced to a lay figure, which the Tycoons had made of him. The rivalry, and honest rivalry, of the parties about him was a guarantee that they would not willingly yield a large pre-eminence to any one of themselves, a change having come over the spirit of the country. In their fulfilment of their duty to the country they exacted from him an oath, which, while it betrays, perhaps, a confusion of ideas, still shows them to have been possessed of broad and liberal views. The Mikado made five vows—1. The practice of discussion and debate shall be universally adopted, and all measures shall be decided by public argument. 2. High and low shall be of one mind, and social order shall thereby be maintained. 3. Civil and military power shall, of necessity, be constituted in a single whole, the rights of all classes be assured, and the national mind completely satisfied. 4. Uncivilised customs shall be broken through, and impartiality and justice, displayed in the working of nature, be adopted as a basis of action. 5. Intellect and learning shall be sought for throughout the world, in order to establish the foundations of the empire.

But many have asked the question why we Europeans go there at all, and have characterised as gross oppression the action of the Western nations in forcing their way into the country. As news arrived time after time of foreigner after foreigner falling by the sword of the assassin, they have justified the act by saying that, as we were not wanted, we had no right to go. Others, recognising the fact that our entry, sooner or later, was inevitable, have maintained that no country has a right to keep itself out of the society of nations, and that we have been fully justified in claiming from Japan friendly intercourse. As experience has already shown, it has proved of immense benefit to foreigners, as well as the Japanese themselves. In the natural intercourse with foreigners light-houses have been erected, and the country partly girded by the

telegraph, while railways have been and are being constructed ; mines are opened and worked, and a great many similar advantages.

After a vote of thanks had been given to the lecturer, the Secretary stated that a most important contribution had been received from Mr. E. Greer, of Liverpool, formerly of Belfast, through the ex-Mayor, Philip Johnston, Esq., in the shape of three idols—Vishnu and his two wives—said to have been taken from the *debris* at the storming of Lucknow. They are composed of bronze, mixed with silver and gold, and form a most valuable prize for the Museum.

April 17, 1872.

JOHN F. HODGES, Esq., M.D., in the Chair.

A Paper was read by ROBERT YOUNG, Esq., C.E. entitled—

THE DUTY OF PRESERVING NATIONAL MONUMENTS.

THE subject on which I propose offering some remarks commends itself to the attention of the educated people of every country, no matter how recent its origin or scanty its history. How much more interest should the cultured classes in these lands take in this matter, where there are historic records and monuments carrying us back with clear and defined steps well nigh two thousand years, and beyond that, pre-historic remains leading us still further back with a feebler light for possibly several thousands more.

A nation's life may be said to be recorded in its monuments—using the word in the widest sense to include everything bearing the impress of man's hand and brain. The weapons, tools, ornaments, and utensils of the earliest inhabitants who raised the earthen raths and duns upon our hillsides and piled the funereal cairns upon the mountain tops, the bronze and gold relics of the following age, and the early Christian examples of art-work in metals and wood, and the illuminated manuscripts which succeed to these, have all a value of their own as embalming some of the life and history of the races who fashioned or used them. Splendid and well-arranged collections of these *moveable antiques* are to be found in many of our towns, besides what may be styled the great national collections in London, Dublin, and Edinburgh, and a very respectable collection has been formed in this Museum. But your attention to-night is to be directed to quite a different class of historic relics than these, and having a

somewhat different and a larger value for the historian, arising from the fact of their being attached to the soil—some, indeed, of the most interesting and earliest type formed of the very soil itself, but each being correctly styled a building—something *set up* or *made fast* at a particular spot, and its value depending mainly on its connection with that place and no other. All the earthworks of our own island, which are variously known as duns, raths, lises, forts, or moats, are more numerous still than in any other country in Europe; the cromleacs, menhirs, and rude stone circles of the earliest times, the round towers, sculptured crosses, anchorite cells, churches, and castles, from the sixth to the fifteenth century, would all be included in this category as historical monuments. Without going the length of saying that the destruction of any one of the thousands of monuments thus referred to would be a serious national loss, it would be a perfectly correct statement as applied to the destruction of a number of the same class, as of the round towers, or the earliest churches, or stone-roofed cells, or again as applied to the case of a monument which is unique or very rare, as our Giant's Ring at Drumbo, or the great raths at Downpatrick and Moylena, near Antrim, both of which are intimately associated with early Irish records of the greatest interest.

To take an illustration from what has occurred in our own neighbourhood within the last generation, the destruction of Trummery Round Tower was a national loss, as from the drawings which represent its aspect some thirty years ago it seems to have been of quite a peculiar type, the only other tower somewhat resembling it being at Dungiven, County Derry; but this, sad to tell, has also been swept away: both might have been saved by care.

Not far from Trummery, but on the south side of the town of Moira, there stood, on the edge of the chalk cliff which here overhangs the Lagan, a very fine mound enclosed by several rings—in fact it was the Moy-rath (*Moira*) which gave its name to the district, and to the famous battle in which Comgall was slain. The levelling of this some years ago by the tenant of the lands in which it stood did not possibly create much indignation in the neighbourhood; still it was an outrage, and a loss which will be felt more and more as education spreads and a better taste prevails.

The modern school of farmers, and more especially those who

have lately migrated from Scotland, with their desire for level ground for their sewing and reaping, are very much inclined to clear off all protuberances, whether pre-historic or recent, and grub up and cart away, or, what equally offends the archæologist, bury in a deeply-dug pit the standing stone or cromleac that interrupts the even tenor of their patent ploughs. To men of this type there is no appeal except through their pockets; but, fortunately for modern antiquarians, it was very different with the old Irish farmer, who had both superstitions and sentiments, the one making him dread the vengeance of the "little folk" if he put a spade into the old rath, and the other causing him to respect the ruined chapel or wayside cross which was from childhood associated with his religious ideas.

Whilst these sentiments are rapidly losing their hold all over the country, it is much to be wished that more correct notions of the real value to the community of such remains should be implanted in their stead. Why should there not be brief notices of the principal antiquities of our country placed in the books of lessons for the National Schools of the Three Kingdoms? and along with this could there not be some instruction in this subject given to the teachers both at the head training establishments and in the Model Schools by a properly-qualified professor? If this were done (and there really seems no good reason why it should not be), a very few years would bring about a marked improvement in the feeling of the lower classes towards these objects. If the constabulary also received some general instructions with regard to the historic antiquities of the districts where they are quartered, they might render very important services; but this may rather be looked on as a part of the intended governmental interference to which allusion will be made hereafter.

That there may be no doubt whatever but that there is an urgent need for some public action to preserve what is still left us of our national monuments, the following facts as to the injury and destruction that is going on in various parts of the Three Kingdoms may be fairly assumed as representing generally the state of things everywhere. To begin with England—the Jews' House, in Lincoln, is threatened with destruction. It is one of the very few specimens of domestic architecture of the twelfth century now extant; and a recent writer calling on the dean and chapter, whose property it is, to preserve it, very truthfully says, "in an artistic and archæological way it is as

valuable as the cathedral itself." At the meeting of the Somerset Archæological Society last Autumn, Dr. Freeman, the president, lamented the way in which the fine old manor houses and parsonages of that county were being destroyed. To quote his own words, "many of these stone houses of the 15th century are among the most precious that remain, although least understood or valued." "The wanton havoc that has been wrought within the last ten years in the one city of Wells is enough to make us tremble for the buildings which have still been spared there and elsewhere. It will be something if we can awaken in the public mind enough of care for these things to save what is still left to us."

Then as regards an earlier class of remains, though not pre-historic, I find at this same meeting attention was called to the way in which the fine Roman camp at Bomer's walls, opposite Clifton Down, was being gradually destroyed. It was stated that soon every trace of the Roman occupation would be gone unless a stop was put to the quarrying. But the loss here is as nothing compared to what was recently threatened to the world-famous Avebury mound in Wiltshire, perhaps the finest pre-historic relic in Europe. After suffering a long series of dilapidations on the part of the adjoining farmers, who used it as a quarry, it was lately proposed to build houses on the inner amphitheatre, and had it not been for the great liberality and promptitude of Sir John Lubbock in at once purchasing the whole ground, this inestimable relic of early English history might have been lost for ever. An eloquent writer in the London *Telegraph* makes this comment on the transaction :—"Thanks to the liberal and intelligent banker, we have escaped the scandal and loss of beholding a page torn from the annals of our land which never could have been replaced, although the Wiltshire proprietors had sold every flock between Marlborough and Salisbury for its purchase."

Turn now to Scotland, and take an instance of what occured in November, 1867, a few miles from Glasgow, its commercial capital. I quote from a letter in the *Builder* of that date, which so admirably expresses the natural feeling of indignation at the removal of ancient *land* and *historical* marks, and shews so well why their chief value depends on their remaining *in situ*, that I give it verbatim :—

"I want to enter an indignant protest against the sale of an

inscribed stone from the Roman Wall (near Castlecary) to the American consul at Newcastle. Why should a *Portland cement* cast be taken for the old castle at Newcastle, whilst he carries off the original? When he has removed it to the United States, it merely becomes an object of antiquarian interest; but whilst it remained *in situ,* about eight miles from Glasgow, in the wall of Antoninus Pius, recording the erection of 3,000 paces, it was such an invaluable portion of irrefragable history that the surrounding inhabitants ought to have felt too proud of having had it bequeathed to them to have ever allowed it to pass out of their hands. By whose permission was this inscribed stone taken out of the wall and delivered over to Professor M'Chesney? It would be wiser to take some Roman monument out of one of our museums and give it to the Professor. This may seem a barbarous suggestion, but it is not half so barbarous as parting with this link from the chain of our national history. I am quite furious about it."

Nor are things any better in the extreme North, as will be seen by an exceedingly interesting and recent notice of the ruined churches of Orkney and Shetland, by Sir Henry Dryden. These were nearly all of Norwegian origin, but since the Reformation period they have been suffered to fall into the most extreme dilapidation, many having fallen within the last twenty years simply for want of a little mortar judiciously applied here and there.

From Sir Henry's description, these churches bear such a striking resemblance to those of the earliest type in Ireland, that there cannot be a doubt but there is here a proof of the missionary zeal of the primitive Irish Church, and the total loss of these records would be indeed deplorable. Is it too late to save some?

Turning now to our own country, and beginning at the Atlantic seaboard, I find from a valuable communication of Mr. Kinahan, in 1869, that the most interesting early buildings on the Connemara Islands are rapidly perishing. Of Ardullaun, he says, "The ruins are all shattered and broken; tradition says they were in good keeping when The Martin held the wilds of Connemara. His successors look more to what can be taken out of the country than what is in it." "One cross only is in a good state of preservation—all the others and any carved stones are more or less injured." Of Innis Boffin he says, "The ancient buildings are all but swept from the face of

creation, only a fragment of St. Colman's Abbey remains of all that this island once possessed."

I find in October, 1870, Sir William Wilde appealing to the public for subscriptions to form a fund to prevent further desecration of Roscommon Abbey, and to repair O'Connor's tomb; at the same time another appeal was being made to repair the top of Ardmore Round Tower, then in a perilous state. Not many weeks ago the Round Tower ot Kilmacduagh, looked on by Irish antiquarians as of the highest interest from Dr. Petrie's references to it in his works, but uncared for and abandoned to its fate, fell prostrate to the ground!

To turn to earlier and ruder monuments than these, we find that everywhere the earthen forts, raths, and megaliths are being swept away rapidly. The great series of cromleacs at Carronmore on Knocknareagh Mountain, in Sligo, associated as they are in such an interesting way with the writings of Beranger in 1791, and Dr. Petrie in 1837, are being destroyed wholesale. Oh for an Irish Lubbock to step forward and save them! Curiously enough the French authorities do not seem to recognise these objects (at least everywhere) as of sufficient value to protect them, for we now hear that in Brittany and Finisterre, and specially at Carnac, a great many are being destroyed. Nor are matters much better nearer home. For the following case I am indebted to a friend who has been in the neighbourhood.

At the beginning of this century there was at Donaghmore, near Dungannon, the remains of an ancient church which had been unroofod in 1641, and afterwards abandoned. It had a very beautiful east window with mullions and tracery of a fine-grained yellow stone. The rector of the parish (who was legally, but in no other sense, the conservator of this interesting relic) was so utterly indifferent to it, that he allowed the stones of the window to be carried off piece-meal to make lap-stones for the cobblers and whetstones for the farmers' scythes, for which purposes it seems it was well suited, and finally he made a present to the parish priest ot the heap of stones that remained to form the foundation of his new chapel.

I mentioned the risk of destruction to which Avebury was exposed and its now undoubted security, and it may be interesting to record that our Giant's Ring, with its central cromleac—a work only

inferior to Avebury in importance—had even a narrower escape some twenty years ago.

The late Dr. Drew having paid a visit to Ballylesson, was taken to the top of the church tower for the fine prospect which it commands on every side. Being pointed out the Giant's Ring at Drumbo, to his amazement and horror he beheld men busily digging into the mound and removing the materials to another place. He hurried into town and wrote a strongly worded letter to the *Ulster Times*, a copy of which was sent to Lord Dungannon, the owner of the soil. His lordship instantly directed that the circle should be inclosed with a proper stone wall, and no further interference with it permitted; and this came not a day too soon, for it then transpired that the levelling of the earthen mound or Ring was only a portion of the *improvement* which the tenant had contemplated on the premises. He had entered into a bargain with a local road contractor, to bore, and blast with gunpowder, and then break into road metalling the huge trap boulders composing the cromleac, commonly called the Druid's Altar. The poor man, utterly ignorant of the value of what was around him, only thought of the trouble he had from the town's folk making a path through his clover field to see the "wheen muckle stanes." Suppose he had completed his ideas of *improvement* without attention being drawn to them, but had been afterwards noticed to leave his farm, and had then made a claim against his landlord under the recent Land Act. Fancy a claim for his outlay in removing the Giant's Ring!

But sad as was the want of taste and feeling for antiquity at Drumbo, a more melancholy and deplorable case of this kind happened not far from where we now are, and is within the knowledge of some old inhabitants of the town. I refer to the destruction of the remains of the famous Con O'Neill's castle at Castlereagh. The owner (I believe the grandfather of the present Marquis of Downshire), hearing that the old castle was much dilapidated, wrote to his agent to enclose the castle field with a wall. His orders were obeyed, but imagine his vexation and anger (for he had a strong desire to protect the old ruin) when he found, on visiting the spot, that every stone of the old pile had been removed and used in erecting the wall, for which piece of economy his agent expected much commendation. Such, then, being some of the risks to which our

national monuments have been, and now are daily exposed, is it not wonderful to think of the apathy and indifference with which even well-educated people are in the habit of looking on, whilst the work of the elements, aided oftentimes by man's ignorance and selfishness, is hurrying them to utter destruction?

It would, however, be unjust not to admit that there has come about a greatly improved state of feeling on these matters within the last thirty years, and specially is this true of the more cultured classes in England, although it is not confined to them. No doubt this is partly owing to the general spread of education and the greater facility for travel, but the chief cause is traceable to the revival of a taste for truthful art and architecture which took place about the time mentioned, aided by the writings of Pugin, Scott, and Ruskin, and more lately by the numerous societies of archæologists in which the best men among the clergy and laity take an active part.

Whilst much is thus being effected both in working out the early history of the country and in saving many historic records which might otherwise have been lost, on the other hand it cannot be denied that the indiscreet zeal of the clergy has in too many instances led to the restoration of churches where, on the process being ended, but little can be recalled of the features that gave such value to the old, and which a wise repairer would have retained.

In Scotland this revival has been only weak and partial, but lately there are symptoms of its setting in with somewhat increased force. The Dundee authorities have lately voted a very large sum of money to repair their noblest monument—the steeple of St. Peter's—the finest example of its class in the kingdom; and it is now said St. Giles' Cathedral in Edinburgh is to be at length cleared out and restored internally to something like its original beauty. It is to be also hoped that the fine old church of St. John, Perth, will not be overlooked, but have its internal rubbish cleared out bodily.

In Ireland, considering that only one association has been doing any active service during the last twelve years or so, it is much to their credit what a large amount of valuable work they have effected with such limited means. I refer to the late Kilkenny—but now the Royal Historical and Archæological Association of Ireland—and may mention the following buildings of great interest, which, chiefly through the exertions of the zealous secretary (Mr. Graves), aided by

members of the association, have been, by judicious repairs, placed in a state of security, viz. :—The Abbey Church of St. Francis, in the town of Kilkenny; the Round Tower of Clonmacnoise; the churches, crosses, and Round Tower at Monasterboice; and it is also proposed to effect similar repairs, as far as can now be done, to the remains of the Seven Churches at Glendalough, County Wicklow.

But, making due allowance for improved public feeling, and for all that these private associations can overtake, it is painfully evident that there is at present no adequate means of dealing with the whole question of national monuments and their due preservation, such as the urgency of the case demands. A strong feeling has, in consequence, spread among those who are interested in these matters that the Government should intervene as it does in France, and under certain circumstances give State protection to these remains.

I think Mr. Pope Hennessy deserves to be remembered as the first who called the attention of Parliament to this subject, about 1864 or 5, and although nothing came of it then, it probably led to the views that were expressed in March, 1869, by Mr. Layard, when Chief Commissioner of Works, as he promised to make a movement to obtain protection for ancient monuments in *England*.

The Historical and Archæological Association of Ireland being naturally anxious that Irish national monuments should be brought within the influence of any measure such as Mr. Layard contemplated, brought considerable influence to bear upon him, and he promised to do what he could for Ireland also. Nothing further seems, however, to have been done except requesting the Society of Antiquaries in London and the Royal Irish Academy, to have a list prepared of all the "Historical Monuments" of the two countries. The former society fell into a ludicrous mistake, for they thought all that was wanted was a list of the royal tombs! The Archæological Institute have, however, taken up this part of the work, but for so far there has been no progress reported from either country.

We now come to the first tangible recognition of the duty of the State in this matter, and it is contained in the 25th section of the Irish Church Act of 26th July, 1869. It provides "that where any church or ecclesiastical building or structure appears to the Commissioners to be ruinous, or, if a church, to be wholly disused as a place of public worship, and not suitable for restoration as a place of public

worship, and yet to be deserving to be retained as a *national monument* by reason of its *architectural character* or *antiquity*, the Commissioners shall, by order, vest such church, building, or structure in the Secretary of the Commissioners of Public Works in Ireland, to be preserved as a National Monument."

The Act is manifestly incomplete in not providing for a properly-qualified inspector being appointed who would examine and report upon the buildings that should be considered National Monuments. Perhaps it is as well that nothing has yet been done under this 25th section of Irish Church Act, as Sir John Lubbock has given notice that he will introduce a bill this session for the Preservation of National Monuments both in Great Britain and Ireland, and I trust this 25th section may be repealed, and all the buildings worthy of being cared for placed under the one control. From a draft of the bill which has been kindly sent me by its author, I find a very simple machinery is proposed to be set up, resembling pretty closely the method pursued in France. Commissioners are to be appointed, who are to be vested with all the powers necessary to carry out the objects of the act. Inspectors to be appointed by them, who will be charged with the duty of looking after monuments worthy of coming under the operation of the commission. Provision is made for compensating all owners whose private rights may be interfered with.

As I have referred to the French system of State protection, I may mention that there are throughout that country a large number of societies of antiquarians who do a great deal of work in their own neighbourhoods, and direct the attention of the Chief Inspector (M. Viollet le Duc) to anything that he may have overlooked, and worthy of being placed on the list of "Monuments Historiques." Before the late war about £40,000 was being expended by the French Government under this head, being mainly in the shape of church restoration under the direction of V. le Duc himself—not a very wise arrangement. In Germany much care is taken of the very interesting remains both of churches and castles, but all this is done by private associations, and the State does not profess to interfere at all. That there are occasions when even there the State should intervene is clear from a statement made by Mr. John Parker, of Oxford, about a year ago. He was at the small town of Zoest, and found that the authorities had determined to pull down a church which had great

historic interest and value. He remonstrated with them, but they said it was of no use, and must come down. He then wrote to the Crown Princess of Prussia, and to his delight, in a short time, he got a courteous reply that she had spoken to the King, and he had given orders that it must be saved.

No doubt this was so far satisfactory, but there is not everywhere and always a Parker on the alert to counteract the effects of ignorance or caprice. How infinitely more wise and constitutional to proceed, as is done in France, to determine by the voice of the educated part of the community, aided by such experts as Viollet le Duc, what are the monuments worthy of State regard. When this is done and the private rights (if such be interfered with) compensated, these are ever after guarded and preserved at the public expense.

It is to be hoped that Sir John Lubbock's Bill will pass this session, although opposition is expected from those who view any interference with private rights as something sacrilegious; however, modern legislation has furnished too many instances of this being done for the public good to make us doubt the final result. I hope, therefore, that a numerously signed petition in its favour will go forward from this centre of education and intelligence to convince Parliament that the sentiment of the people here demands it.

As regards funds for carrying out the Act in Ireland, there could be nothing so well entitled to, and eligible in every way to receive a portion of the residue of the Church property as this, many of the Irish monuments being of an ecclesiastical character, and, along with this appropriation, it would be most desirable that at least a selection from the large mass of the Irish Ordnance Survey documents—collected with such care by Petrie, O'Donovan, and their assistants, and useless in their present state—should be published by the Government, a further portion of the residue being granted for that purpose also. I have no hesitation in saying that Irishmen of every creed and class would agree in considering both these objects more worthy of being classed as residuary legatees under the Irish Church Act than our county lunatic asylums.

Obituary Notice of the Late Robert Patterson, Esq., F.R.S.,

By A. O'D. TAYLOR, Secretary of the Society.

[*Reprinted from the "Northern Whig" of 15th February*, 1872.]

It would be a breach of what is due to the public, and most foreign to our own feelings of respect for departed worth, were we to allow the death of our esteemed fellow-townsman, Robert Patterson, Esq., to pass by without some special comment.

At the time of his decease, which took place on Wednesday, the 14th Feb., 1872, at his residence in College Square North, Belfast, he was in his seventieth year, having been born on the 18th of April, 1802. Much as his death would be regretted at any time, circumstances render it peculiarly so, as it may be attributed to the effects of an accident. He stumbled in his own bedroom on the 5th of last December, fell heavily, and a fracture of the thigh bone was the result. From the effects of this fall he never recovered. Cerebral symptoms supervened, and it became evident to his relations, within the last three weeks, that the end was gradually approaching. They were, therefore, not unprepared for the sad event which we now chronicle.

Mr. Patterson's high reputation for moral integrity, and for literary acquirements, has been known to the community for many years. In fact those who are now bearing the heat and burden of the day, as men of middle age in the various associations connected with civic life, can look back to the days of their boyhood and youth as a time when Mr. Patterson's name had become quite familiar as one which added lustre to Belfast, and as borne by a gentleman who furnished an honourable example to those around him. Most men seem to find commercial pursuits so engrossing, that when once deeply engaged in them, literature and science become neglected, or

only valued for their bearings on material prosperity; but there has always been a small band of men in Belfast, recruited from generation to generation, men of special force of character, who have known how to be successful in business and at the same time eminent in higher walks of intellectual effort. Mr. Patterson was a man of this stamp. The peculiarity of his career consisted in his having discharged his duties as a man of business, with marked prudence and success, while at the same time he found leisure to think and study, and write about his favourite pursuit, natural history, with such ability as to earn a high place among popular scientific authors. In his business—and the transactions of his firm extended throughout England and Scotland as well as Ireland—Mr. Patterson was highly esteemed for punctuality and integrity in his dealings. He was the reverse of speculative, and weighed all transactions well before embarking in them. Caution was one of his leading traits, and this constitutional prudence steered him, through life, clear from those inconveniences in which men of more ardent impulses, but possessing less judgment, often become involved. As a man of letters, his style was polished and graceful, and the same nicely-balanced judgment always characterised his oral addresses. Without aiming at any high flights of eloquence, his speaking in public was conceived in good taste and feeling, was finished in diction, and frequently, when the subject permitted, displayed considerable poetic power, both in description and illustration. Whenever duty required it, Mr. Patterson accepted and filled faithfully various posts of trust in connection with public bodies and committees, civic, educational, and philanthropic. Courteous and genial in his manner, as all of those who were in the habit of meeting him can testify, his conversational powers rendered him an agreeable and instructive companion, while his gentleness of disposition in the sacred relations of domestic life endeared him to all those with whom he was connected. Averse to wounding the feelings of any one, the arena of politics was not a congenial one to him, on account of the acerbity too often mixed up with political questions; but his sentiments were those of a moderate Liberal. His religious views were Unitarian, and his walk in life was a practical exposition of his Christian profession. We believe he was one of only four survivors who, at the commencement of this year, remained out of eighty-eight persons who in 1831 signed a call to the Rev.

John Scott Porter, then of London, to assume the joint pastorate with the Rev. William Bruce (now deceased) of the First Presbyterian Congregation, still worshipping in Rosemary Street, Belfast.

As already mentioned, he was born on the 18th of April, 1802. His birthplace was Belfast, where, in the year 1786, his father established the ironmongery and hardware place of business at the corner of Bridge Street and High Street, a concern still held by the family. Mr. Patterson was chiefly educated at the Belfast Academy, when the Rev. Dr. Bruce was its principal, but partly at the Academical Institution. In the latter seminary he sat on the same benches with boys who in after life filled conspicuous posts under Government, at the bar, and in the world of letters. His own personal feelings of affection for the Institution, and the memory of the happy days of his school-boy life there, remained with him to the last, and nothing seemed to give him greater pleasure than revisiting the old familiar spot on occasions of "breaking up" and distributions of prizes, and then addressing a few words of encouragement to the young people. In his early days, we believe, he contemplated the Irish Bar as a profession ; but the calls of his father's business seeming to require his assistance, he determined to devote himself to mercantile pursuits, and accordingly entered his father's place of business when he was about sixteen years of age. His father's death, occurring in 1831, placed him at the head of the firm. In 1833 he married the daughter of William Hugh Ferrar, Esq., a gentleman who was stipendiary magistrate for Belfast, and who had died some years previously, from fever caught in the discharge of his official duties.

At an early age Mr. Patterson's spare hours were devoted to a perusal of the British poets, and as he possessed that appreciative power of observing and enjoying Nature, both animate and inanimate, for which Wordsworth was pre-eminently distinguished, his tastes also led him to the study of works on natural history. Very early indeed in life, the dictum of Paley seems to have implanted itself in his mind—namely, that if one train of thinking be more desirable than another, it is that which regards the phenomena of Nature with a constant reference to a supreme, intelligent Author. It was this tendency which had actuated him to join in 1821, with six other young men of like pursuits, and under the guidance and presidency of Dr. James L. Drummond, to form the Natural History Society of

Belfast, now known under the more comprehensive title of the Natural History and Philosophical Society. Of the eight individuals referred to, the only survivors now are the Rev. William M'Clure, of Derry, and Dr. Francis Archer, of Liverpool. This society held meetings, at which lectures of a popular character were regularly delivered. Amongst these there was a most attractive series by Mr. Patterson, "On the insects mentioned in Shakspere." These lectures were subsequently thrown into an epistolary form, and published in an octavo volume in 1838. As a further contribution towards the elucidation of the natural history of our great dramatist, a few pages on the "Reptiles" appeared in the "London Zoologist" for 1843. Mr. Patterson contributed to various scientific periodicals; we may instance three papers which attracted much attention, one on "Snow Crystals," in the "Magazine of Natural History" for 1838; one in same magazine in 1839 on the "Common Limpet;" and one in 1842 on "The appearance of Clouds of Diptera." One on "A Species of Beroë found on the Irish Coast," appeared in the "Edinburgh and Philosophical Journal" for 1836. This little creature had been frequently captured in 1835 by Mr. Patterson near Larne. His observations on this and on a larger species were published in "The Transactions of the Royal Irish Academy" (volume 19). In November, 1840, Mr. Patterson delivered a lecture in the Belfast Museum on "Natural History as a branch of General Education in Schools and Colleges." This was printed, and had an immense circulation. Later on, he contributed articles to each of the first three volumes of Mr. Edward Hughes' series of "Reading Lessons," and a paper entitled "Life at the Seaside," to "Constable's Educational Series." Again, in 1844, we find him at his favourite post in the Belfast Museum, lecturing with that peculiar felicity of manner and illustration for which he was remarkable, on those lower animals then included under the term "Radiata." It may be remarked that the lower orders of animated creatures, and especially marine animals, were his favourite subjects. In the investigation of these, the microscope, which was a favourite companion in his resources, afforded him incalculable assistance. Without losing the thread of his natural history progress, we may quote here, for the double purpose of showing how thoroughly alive his sentiments also were to unorganised nature, and as a proof that his poetic powers were

of no mean order, the following lines, written by Mr. Patterson, on

"THE GAP OF DUNLOE—KILLARNEY."

"Here let us stop ; this glorious scene demands
Our more minute observance. The hills around
Have girt us in—their lofty heads, enwrapped
In misty wreaths, permit the mind to dream
Of more aspiring summits than the truth
Might offer to our gaze.
The arbutus blossom bows in gentle rest !
The oak leaves quiver not ; the drooping bells
Of the sweet heather are not trembling now !
The dazzling pennons of the furze are still !
There is not even a gaudy fly afloat ;
Nor doth the humming music of the bee
Break on the solitude—even the silver breast,
The dream-like waters of that little lake
Are undisturbed ; no struggling sunbeam sheds
A glancing radiance o'er its glassy calm.
How deeply doth such solitude affect !
How very soothing to the human heart,
Scenes of such peace ! what fairy-like repose
Reigns over all ! 'tis as if nature slept ;
Or, like the landscape of a pleasant dream,
Where all is sight, and sound intrudeth not."

Continuing the review of his scientific labours, we find that having now by many years of thought and study extended his own information and matured his ideas, Mr. Patterson, in 1846, put into execution his long-cherished plan of laying before the public a work on zoology, suitable for use as a class-book in schools. At this time the want of such a book was much felt, as the writings of naturalists and closer attention to what should constitute a really good education were more and more directing public attention to the advisability of adding natural history to the subjects taught in public and private schools. Accordingly, in 1846, appeared Mr. Patterson's "*Zoology for Schools*, 1st Part." We cannot do better than quote the opening sentences of the preface to the first edition :—"I have for years been anxious that natural history should be made a regular branch of education, because it exercises both the observant and the reflective powers ; furnishes enjoyment, pure and exhaustless ; and tends to make devotional feelings habitual. The present little work has been undertaken in

the hope that it might conduce to such a result. In its preparation I have aimed at conveying correct ideas of the peculiarities of structure by which the principal divisions of the animal kingdom are distinguished, and of the habits, economy, and uses of one or more of the most common native species belonging to each of these groups." The conception and execution of this book were so highly regarded that, in addition to being largely purchased for middle-class and higher schools, its introduction into the Irish National schools was recommended by the Commissioners in Marlborough Street, Dublin, and this, of course, extended its circulation over the whole of Ireland. The Council of Education for England also adopted it as their natural history class-book for England. The second part of this work appeared in 1848, and met with a similar cordial reception.

The use of this work led to the discovery that even a more rudimentary treatise could be used with advantage by junior classes. This caused the preparation of "Patterson's First Steps to Zoology:" Part I. Invertebrate Animals, Part II. Vertebrate Animals. These two small volumes are also extensively used. All of the books were copiously illustrated, for Mr. Patterson always recognised the necessity of teaching simultaneously by the ear and the eye.

As time went on, school-teachers felt the want of even larger illustrations; and the wisdom of grouping together various organisms belonging to one family, and therefore allied to each other in structure though diverse in appearance, become apparent. This led to the issue in 1853 of "Zoological Diagrams," large coloured plates which have proved of material assistance to both the teacher and the taught. The preparation of these plates was due to a suggestion from Sir James Emerson Tennent, an old friend of Mr. Patterson's. With the aid of the eminent artists, Wolf, Ford, Bailie, and Tuffen West, and the careful lithography and hand-colouring of Messrs. Day & Son, these diagrams, ten in number, proved very successful. Looking at these publications and at their results, it is not too much to say that the labours of no man in Ireland have been so successful as Mr. Patterson's, in popularising the general study of natural history, and in advancing it to its rightful place as a recognised branch of school education.

Early in the history of the British Association, Mr Patterson became one of its members, and was elected one of the secretaries of its

natural history section in 1839. He held that post till 1844, when pressure of other engagements led him to resign it. During part of that period his co-secretary was the late Professor Edward Forbes, for whom he always entertained the strongest feelings of friendship and regard. As many of our readers will recollect, Belfast enjoyed the honour of a visit from the British Association in 1852, on which occasion Mr. Patterson officiated as local treasurer. It is not generally known that the introduction of the daily printed "programmes," which those who have attended meetings of the British Association know to be almost invaluable, was entirely Mr. Patterson's idea. His business mind and love of accuracy saw the want of such a guide for large assemblages, and devised the means of daily supplying the want in the simplest form. With the public of Belfast Mr. Patterson's name and the Museum have been long identified. The building, which now contains not only a general collection from foreign countries, but also collections specially illustrative of the fauna and flora of Ireland, was erected by private subscription, in 1830-31, and Mr. Patterson was actively instrumental in its erection, and the subsequent collecting together of the objects it now contains. The formation of the Belfast Museum originated with the members of the Natural History and Philosophical Society; and it must be a pleasurable recollection to the shareholders and members connected with that institution, to reflect that last summer (1871) they paid the gentleman, whose removal we now deplore, the greatest compliment in their power. Mr. Patterson had in June, 1871, completed the fiftieth year of his active connection with the society, and, to mark their appreciation of his valuable services, and to congratulate him on a half century's faithful work, they met on the 11th September, 1871, and presented him with a beautiful illuminated address. This address was enriched by hand-drawings around the pages, illustrating the various objects on which Mr. Patterson had written, and was signed by a very large number of the leading men of Belfast and its neighbourhood. We have reason to know that Mr. Patterson valued this proof of kindly regard from his many friends very highly indeed.

We have enlarged so much on Mr. Patterson's scientific and literary life, that we must dwell but briefly on some points of his business and civic career. In business he was associated for some years with his younger brother, Mr. William Patterson, who died in

1837, and with another younger brother, Mr. David Patterson, who died in 1847. A sister died in 1857, and, as the family originally consisted of four, the subject of this memoir was the last survivor.

Mr. Patterson was always accustomed to take part in the business of different public boards in his native town, and to act on the committees of societies congenial to his taste. He was one of the original members of the Belfast Society for the Prevention of Cruelty to Animals, founded in 1836, of which his eldest son, W. H. Patterson Esq., is now one of the secretaries. In 1849 he was elected on the local committee of the Northern Banking Company, an establishment in whose prosperity he always evinced much interest. On this committee he remained, with brief intervals, until the date of his death. He was elected a member of the Harbour Board on 29th June, 1858, and retired in October, 1870, being anxious, as he felt years increasing, to divest himself of most situations of trust. He was much esteemed as a Harbour Commissioner by his fellow-members; and by his judiciousness and clearsightedness often proved himself most valuable in council. It was by his suggestion that the meteorological department was added to the Harbour Office, connecting it by wire with the English system of observations originally established by Admiral Fitzroy. The People's Park was also a matter to the satisfactory arrangement of which Mr. Patterson devoted much consideration. In 1860 he was elected a Town Councillor against his own wishes; but, as at that time an amalgamation of parties was attempted, to further public interests, he consented to act, and served from 25th November, 1860, till 25th November, 1863. At the time when several other gentlemen were created borough magistrates, some years ago, Mr. Patterson was also nominated a justice of the peace; but he never qualified, the honour not being one which he thought he could use beneficially. The distinctions which he prized were scientific; and this feeling was honorably gratified by his having been elected a Member of the Royal Irish Academy in 1856, and some years later a Fellow of the Royal Society of London. In 1865 he retired from all partnerships in business, leaving to his eldest son the old concern known as 40, High Street, and having settled all his other sons satisfactorily in various walks of life. He leaves five sons and

four daughters, and the estimable lady to whom he was united in 1833 also survives him. We do not pretend to have enumerated all the associations or enterprises with which Mr. Patterson, during his long life, has been connected. He was always ready to join in any effort tending to ameliorate society, and always glad to make more generally known any new application of science to the affairs of ordinary life.

He gave considerable time to the interests of the Savings' Bank in King Street, during several years of its existence. In connection with the working classes, he strove earnestly for the establishment of the public baths and wash-houses on the Falls Road, and it was with much regret that he saw the undertaking drift into failure. As a committee-man at the Linen Hall Library and the Botanic Gardens, he was also, some years ago, most zealous and active. Many years since—we think about the years 1845-48—there was a scheme to run a railway, driven by atmospheric pressure, between Belfast and Holywood. At that time the short line between Kingstown and Dalkey had been started, and, though since abandoned, was then proving tolerably successful. Mr. Patterson acted as secretary to the company projecting the Belfast and Holywood atmospheric line, but Parliament refused to grant the Bill. Of late years, Mr. Patterson had been quietly withdrawing from very active work, though still serving on many committees, such as that of the Royal Belfast Academical Institution, the National Education League for Ireland, the Domestic Mission to the Poor of Belfast, &c. For the last fourteen years Mr. Patterson had invariably spent the summer with his family at Marino Villas, near Holywood, County Down ; and we are sure that in Holywood his loss will be as much regretted as in Belfast by the large circle of friends whom he was constantly meeting on terms of familiar intercourse during the summer months.

We now close this sketch, which only purports to touch upon some of the salient points of Mr. Patterson's character and career. In doing so, we avoid touching upon private feelings, yet we cannot refrain from expressing our most deep and respectful sympathy with his life-long partner, the honoured lady who is now his widow. But if to her, and to his sons and daughters still with us, the memory of a long life faithfully spent, the survey of talents employed in

elevating the sentiments of others, and the assurance that public esteem does not terminate with the career now closed, if—we repeat—these thoughts can serve to soften the pang of separation, such reflections cannot, in the present instance, fail to operate most powerfully.

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